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ABSTRACT

Although the concept of automated instruction is not new, it has gained major support only in the past 3 years. These 12 papers describe research in the area of instructional methods for technical training. The scientific principles of learning and their applicability to automated instruction are discussed, with emphasis on the role of automated instruction as a supplement to, rather than a replacement for, existing institutions and teachers. The papers include: (1) "Preliminary Studies in Automated Teaching" by R. F. Mager, (2) "Automated Instructional Methods for Technical Training" by P. G. Whitmore, (3) "Deriving and Specifying Instructional Objectives" by P. G. Whitmore, and (4) "A Rational Analysis of the Process of Instruction" by P. G. Whitmore. (BH)

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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation and leadership.

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Prefatory Note

In Work Unit TEXTRUCT, the Human Resources Research Organization undertook a program of research directed toward the development of efficient and effective instructional techniques that would be applicable to the extensive program of Army technical training. The research took place during the years 1958-64; it was conducted at HumRRO Division No. 5, at Fort Bliss, Texas.

The papers in this collection were presented at military and professional meetings or appeared in professional journals during the course of the research on Work Unit TEXTRUCT. Other publications under this Work Unit are listed at the back of this publication.

Because of the continuing relevance of the subject matter of these papers, they are being issued in a group as part of the HumRRO Professional Paper series. This series was initiated in order to provide permanent record of specialized aspects of HumRRO work, and deposit in the scientific and technical information storage and retrieval systems of the Department of Defense and the National Technical Information Service.

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TEACHING: TODAY AND TOMORROW[1]

Robert F. Mager

In this paper some principles of learning and some facts about the teacher-learner situation in the modern setting are discussed. Purposes and methods of automating instruction so that students will be able to learn more—and teachers teach better—are presented. There are descriptions of several teaching devices.

During the past 50 years we have seen tremendous advances in many disciplines. We have seen communication progress from the crystal set and the telegraph key to color television and microwave. Data processing has moved from the simple adding machine to huge electronic computers that can handle millions of bits of information and perform millions of operations per second.

The tools of astronomy have blossomed from the simple optical telescope to the huge radio telescopes that look far out into the universe; and aviation has exploded from nothingness into supersonic flight, space ships and satellites.

With each new development, with each advance, has come an increase in the number of facts and in the number of equations to be learned. As the mountains of knowledge grow higher it becomes increasingly necessary for the student to assimilate greater amounts of material before he can be considered competent in his chosen field.

The young science of learning has also made progress during the past 50 years, although seemingly insignificant when compared with the great strides made in the areas mentioned above. But even the progress which has been made in the science of learning has not been applied to the learning environment. The technology of learning has not kept pace with the science.

The present techniques of education have long been inadequate and become even more noticeably cumbersome as the amount of information which must be mastered by the student increases. We have approached the point where we can no longer afford the luxury of an outdated technology of learning.

Though we do not pretend to know a good deal about the learning process, there is, nevertheless, a vast chasm between what we know about learning and what we *do* about it. There are several principles of learning which have been sufficiently validated by research which, if applied, would increase learning efficiency. There is a fairly respectable body of knowledge which, if utilized, would undoubtedly make a startling difference in the amount of material which could be mastered per unit time.

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[1] This article appeared in *IRE Student Quarterly*, September 1959.

SOME PRINCIPLES OF LEARNING

Here, in as nontechnical terms as possible, is a description of some of the learning principles which are known but which, for the most part, have been left to lie idle.

PRINCIPLE OF PARTICIPATION: This principle explains that learning is more efficient when the learner is called upon to make frequent responses relevant to the skill being learned; that is, when the learner participates in the learning. More simply, we learn by doing.

Example: If you were watching a film on the tuning of an IF strip you would learn more if you were required to answer questions during the film than you would if you simply relaxed while watching the film from beginning to end. You would learn even better by actually tuning an IF strip.

PRINCIPLE OF KNOWLEDGE OF RESULTS: Learning is more efficient when the learner is apprised of the accuracy or appropriateness of his responses, when he receives feedback as to how well he is doing.

Example: If you were trying to learn to fire a rifle your accuracy would probably not improve unless you could see where your shots were hitting.

PRINCIPLE OF IMMEDIACY OF KNOWLEDGE OF RESULT: For knowledge of results to be most effective it must follow immediately after a response. In other words, we learn by doing, and by knowing right now how we did. The term "immediate" here means within a few seconds after the response.

Example: You take an examination, and two or three days later your paper is returned. Though such a procedure is quite legitimate when the exam is used for the purpose of determining your progress, it is all but useless when the exam is used as a learning device.

PRINCIPLE OF REINFORCEMENT: Learning is more effective when the learner is rewarded (more technically, reinforced) for correct responses. This is a very tricky principle to apply, however, because it is frequently difficult to know just *what* is reinforcing to a particular individual; what is rewarding to one may not be rewarding to another.

Example: After being a poor student for most of the semester in mechanical drawing you finally produce a good-looking piece of work. The instructor does handsprings and shows your work proudly to his colleague. The probability increases that your mechanical drawing skill will improve.

INDIVIDUAL DIFFERENCES: It has been a truism in psychology for many years that there are individual differences. People differ in their basic intelligence, in their skills and abilities, and they differ in the rate at which they learn. The structure of most of our educational system ignores this basic fact of human behavior, however, in that a single instructor is expected to fill simultaneously the needs of large numbers of different and differing individuals. But as we shall presently see, none of the principles discussed are applied very well in this traditional environment. Regardless of the instructor's skill or enthusiasm the very structure of the learning environment stacks the deck against him—and the student.

With a single teacher and a single learner these principles can be applied with some degree of efficiency. To see how this can occur it will be useful to consider what happens in the teacher-learner situation.

THE TEACHER-LEARNER SITUATION

The teacher-learner situation is very much like a transmitter-receiver system, where the object is to transfer information from the transmitting unit to the receiving unit with as little loss and distortion as possible. With electronic systems this goal can be achieved rather readily. In servo and selsyn systems a high degree of information transfer can be accomplished through relatively simple circuitry, and such transmission can be made even more efficient when a feedback loop is employed. With human systems we are not quite so lucky. Much information is lost during transmission because of such factors as inattention, motivation—or the lack of it—and inappropriate transmission rate. Because of this state of affairs provision for feedback is even more essential, feedback which will allow the teacher to determine whether information was received and how accurately it was received, every step of the way.

With a single student the teacher can provide information to the student, an item at a time, and then check to see if the student "got it" and whether he got it correctly. On the basis of this feedback the instructor can then determine what he should tell the student next. He can modify his teaching program to fit the needs of the learner.

As the learner makes each response, the teacher can provide him with immediate feedback in the form of knowledge of results. He can reinforce correct responses (by telling the student he is right), and he can decrease the probability of an error being repeated by withholding reinforcement when errors occur and by providing corrective information. Thus, in this kind of situation, the student participates actively in the learning, receives immediate knowledge of results after each response, is reinforced for correct responses, and is allowed to proceed at the rate best for him.

But a description of the single teacher-learner situation is not a description of the most commonly used learning environment. We are very seldom in a learning situation where we enjoy such attention. In fact, harking back to our transmitter-receiver analogy, we find that we usually have a situation wherein a single transmitter is beaming information at anywhere from 10 to 250 receivers, each of which has band-pass filters tuned to drop out different bits of information (individual differences again). A best, a single transmission rate will be optimal for only a small percentage of the receivers.

In the classroom as we know it, it is very difficult for a single instructor to arrange for students to make frequent relevant responses, and it would be next to impossible for this single instructor to provide selective knowledge of results even if students were participating frequently. So even if efficient feedback were possible to achieve in the classroom the best the instructor could do is maximize his instruction for only a small proportion of students.

It is almost impossible to effectively apply most of the principles of learning in the classroom as we know it. Not because the instructor is inadequate or unenthusiastic (though the signal-to-noise ratio of some transmissions has been known to approach one-to-one, but simply because the configuration of the learning environment does not allow these principles to be applied. Another way of saying this is that even though we are aware of such fundamental behavioral facts as individual differences, we don't do very much about it. Even though we have known for a long time that people learn at different rates, and even though we know that to be most effective the learning environment must be tailored to the individual, we still put large groups of students in front of a single instructor and insist that they all learn at the same rate. Though this may be a convenient way of doing things, or economically necessary, it isn't very efficient.

THE PROMISE OF AUTOMATION

Such a situation need not be perpetuated. New methods of instruction are under development which promise to provide students with the means whereby they can learn more things in less time, and which promise to provide the instructor with long overdue relief from the more menial and monotonous aspects of his job.

The methods to which I refer are those involving the automation of instruction and the use of teaching machines (more accurately, teaching devices). Such devices are not mere training aids or audiovisual gadgets, nor are they mechanical oddities which will produce regiments of human robots. Rather, they are devices which, like private tutors, carefully present information to the individual learner in small steps, require him to participate in some way in the learning, provide the learner with immediate knowledge of results, and allow each learner to proceed at the rate best for him. In other words, a teaching machine is a device which has built into it a relatively efficient feedback system; the device and the learner constitute a closed system. The device provides feedback to the student which tells him how well he is doing every step of the way, and the learner's responses provide feedback to the device on the basis of which it can modify its program so as to provide the learner with exactly that information or guidance he needs next.

The effort to automate instruction is not new. You may be as surprised as I was to learn that the first teaching machine was patented by Halcyon Skinnar as far back as 1866, and his device appears to be about as good as some in use today. (A copy of this patent, No. 72758, may be obtained from the U.S. Patent Office for 25 cents.) Apparently little came of his efforts and nothing much happened until 1924, when Dr. Pressey of Ohio State University developed some devices which would test and teach. Again the world wasn't ready and after several years without any encouragement whatsoever Dr. Pressey turned to other pursuits. Today, however, an ever increasing number of researchers and educators are becoming actively interested in the automation of instruction.

Researchers who are working to develop the principles of instructional programming and the devices through which these programs are presented are creating a learning environment which will be more efficient than that of the traditional classroom, because it will be an environment incorporating the science of learning. These researchers are developing a technology of learning based on the science of learning.

Though there are relatively little data describing results of teaching by automation, those which are available are highly encouraging. Briefly, a first semester German course has been successfully taught by a teaching device in approximately 40 hours, and a college algebra course has been taught in 30 hours. When the students of an average college psychology class took the course by teaching device the standard final exams had to be revised; the median final score was 94% and no student made less than 85% on the exam.

We have been trying to explore the limits of teaching devices and learn about programming techniques by giving college algebra problems to 11- and 12-year-old children. Even when this material is presented by a device as simple as a specially prepared manila folder, we find that these students can learn a significant portion of the content. Even though these students are generally considered to be below the age of "readiness" to learn such material as college algebra they are, in fact, able to master a significant portion of it when it is appropriately presented in small steps. One of the most unexpected observations from this preliminary work came from the youngest subjects, who have a rather severe but traditional dislike for the mathematics they are being taught at school. Even though they were learning such content as the associative and distributive laws, absolute numbers, and the manipulation of signed numbers, they refused to believe that this had anything to do with mathematics because they could understand it.

The same sort of thing happened when the concept of the kinetic theory of gases was programmed by Dr. Day and given to juniors in a course in physical chemistry at Ohio University. Some of the students found the subject matter so easy when presented in this manner they considered it an insult to their proud intelligence. They learned the material, you understand, but complained that it was too easy. Apparently, somebody has been teaching students that learning can be neither pleasant nor simple; whoever it is ought to be ashamed of himself, because it does not need to be so.

What the limits are in the effectiveness of programmed instruction we don't yet know. So far, subject matters which have been successfully automated or semi-automated include physics, chemistry, psychology, languages, statistics, and art. Though there may be some subjects which either cannot or should not be automated, we do not yet know what they are.

METHODS OF PROGRAMMING

The automation of instruction requires, first, the preparation of the program and, second, construction of the device or medium through which the program will be presented. But as important as the device may be, the critical aspect is the programming. Without proper preparation of the program, without careful breakdown and sequencing of the content to be taught, the most beautiful and complicated device is of little value.

Let's consider two of the methods of programming and how they might be presented to the learner. One method, the sequential program, presents information to the student one frame (item) at a time and might, for example, require the student to write his response to the frame either into the device or on a separate sheet of paper. As soon as he does this, the device shows him the correct response (answer), providing him with immediate knowledge of results. The second frame (item) then appears; again the learner writes his response and again the device immediately provides knowledge of results. Frames are constructed and sequenced in such a way as to lead the student from a state of ignorance to one of complete mastery. With the sequential program the student is presented with every item of the sequence, and information is presented in such small steps and in such a way as to encourage the learner to make correct responses to almost every frame.

Here are a few sample frames of a program to teach some facts about fractions Note how the information is presented in very small steps, how the learner must respond to each aspect of the material, and how the program gradually leads the learner toward an understanding of the material.

1. Fractions can be both common fractions and decimal fractions. 2/5 is a common_________.	fraction
2. 1/3 is a_________fraction.	common
3. 11/16 is a________ ___________ .	common fraction
4. The number above the dividing line in a common fraction is the numerator. In the common fraction 2/3,the numerator is_________.	2
5. In the common fraction 1/3, 1 is the_________.	numerator
6. In a common fraction the numerator is the number_____ ___ _________ ______ .	above the dividing line

7. The number below the dividing line in a common fraction is the denominator. In the common fraction 2/3 the denominator is ________.	3
8. In the common fraction 11/12, 12 is the __________.	denominator
9. What is the denominator of a common fraction? ________ ______ __________ __________.	number below dividing line
10. In 6/11 the numerator is (a) ________, and the denominator is (b)________.	(a) 6 (b) 11
11. In 17/41 the denominator is (a)________, and the numerator is (b)__________.	(a) 41 (b) 17

How is a sequential program presented to the learner? A simple device constructed by the writer for this purpose is shown in Figures 1, 2, and 3. The frames appear in the window at the left and the learner writes his response on a separate sheet of paper. He then lifts the flap of the "answer" window to check the accuracy of his response.

If he is correct, he checks his answer; if he is not, he crosses it out and writes it correctly. He then rolls the next frame into view with the wheel under his left thumb. As you can see, the "innards" of this device look suspiciously like the information rolls found in tube testers. More automatic devices have been constructed through which this kind of program can be presented, devices which can tabulate the number of correct and incorrect responses, and which can phase the learner forward to more difficult material if he achieves, say, five correct items in a row. Less automated devices have also been used, since complete automation is not necessary to achieve good results; it's the program that counts.

Another method, that of alternative programming, samples the student's output every step of the way by requiring him to select an answer rather than create one. With an alternative program, the learner is not given every frame of the program. The learner's response to the device determines the information to be presented next. Here, after being presented with the first item of information or task, the learner's understanding is tested by a multiple-choice question. He may indicate his alternative to the machine by pressing an appropriate button or by operating a switch. The device selects the material to be presented next on the basis of the learner's response. If the learner were correct the machine might respond, "Your answer was 'impedance.' YOU ARE CORRECT, since you saw that both capacitive and inductive reactances are present in this circuit," and then present the next piece of content. If an incorrect alternative were chosen by the learner the machine would respond in a way calculated to reduce the likelihood of the error being repeated, and in a way which would help the learner to understand the material. If, for example, the learner made a simple error in calculation the device might tell him, "Your answer was '50 ohms.' Though you seem to understand the principle involved here you apparently

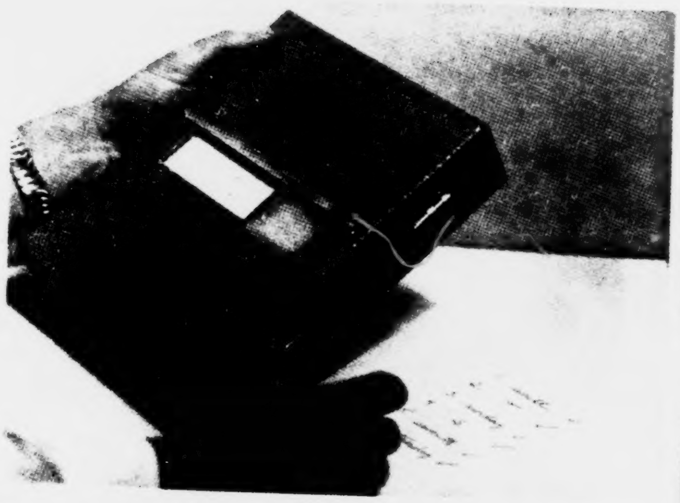

Fig. 1. This small device is used for presentation of a sequential program.

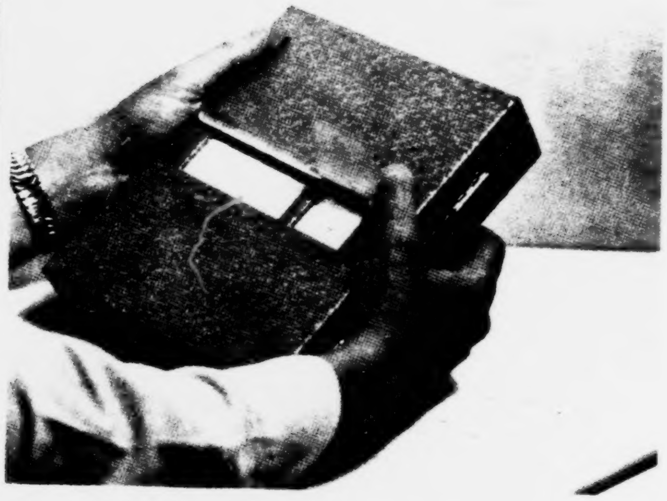

Fig. 2. A learner compares his response with the correct one appearing under the tab.

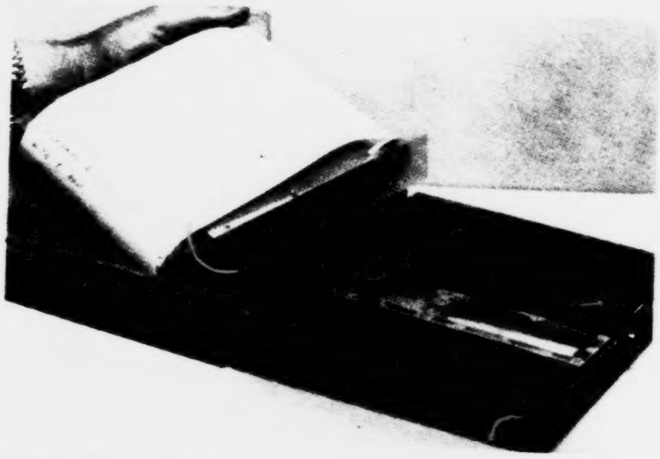

Fig. 3. The mechanism of this device is extremely simple. Construction resembles that used to visualize the information rolls found in many tube testers.

added 2 and 2 and got 5. I suggest you slow down a little so you can take more care with your calculations. Now let's try it again." If the learner's choice could only have been made on the basis of a wild guess he might be told, "One megohm? Now, come on. You're just guessing. Perhaps we'd better back up a few steps and work our way forward more slowly." Here again the learner is carried along at the rate best for him. He is active in the learning and is provided with immediate knowledge of results. By now you can see that machine teaching is not a "mechanical" affair; it is just as personal and intimate as the programmer cares to make it.

What kind of device is used to present the alternative program to the learner? One which has been constructed used rear-screen microfilm projection. The learner indicates his responses to the machine by pressing an appropriate button, and the device then selects the frame to be presented next and projects it on the screen provided for this purpose. Though the devices used to present the alternative program are generally more complex than those used to present the sequential program, it happens that the alternative program can be presented by a device as simple as a properly constructed book. Suppose, for example, that the first item of information were presented on page 20 and that the test item appeared at the bottom of that page. Suppose further that each answer to this item were numbered with page numbers. Now, when the learner chooses his answer he turns to the page indicated by that answer and reads the information appropriate to that response. If he is correct he is reinforced and the next item of information is presented. If he is incorrect he gets correctional information, followed by another problem. He is given as many explanations and problems as are necessary to understand the material, and he is not phased forward until he does. This device is sometimes called a "scrambled book" or "programmed book" and can be quite an effective teaching instrument.

THE NEED FOR DEVICES

Even though the program is the most important aspect of automated instruction, the need for specialized hardware should grow fantastically during the next five years, and many engineers will find opportunities to make major contributions in another new field. Currently, there is a need for research instruments of special design. We have approached the point where the limitation in versatility of current devices prevents explorations of the variety of configurations and situations necessary to the development of the most efficient learning environment. We need research equipment with sufficient versatility to allow us to vary systematically all the variables which affect learning. Such devices must provide for the acceptance and recording of different kinds of learner responses. A device for teaching electronics would ideally allow for presentation of subject matter through several modalities; visual, in the form of printed matter, film strips and film clips; auditory, in the form of verbal instructions and equipment sounds; tactual, so that learners could be made to "feel" the meaning of such concepts as "too hot" and "excessive vibration," and possibly even olfactory, so that the learner could be presented with the odor of a burning transformer. This kind of device will be used for research aimed at learning how to maximize the learning situation.

An entire family of self-testing and review machines is needed. Such devices must be capable of being rapidly loaded with as many as 1,000 test items, must be relatively small and easy to operate, and must be very rugged. Experience with prototypes of these machines indicates that when such a self-testing machine is made available to students it is used until it is worn out. Why shouldn't there be several hundred such machines spotted around a university campus, each loaded with test and review items covering different subjects? We know that, when available, students will spend a good deal of time "playing" such machines; here is a wonderful opportunity to turn the pin-ball craze into something profitable for the player too.

There is need for another family of devices which, rather than teach a particular content or skill, will be built for the purpose of increasing the proficiency with which an already learned task will be performed. Such devices will encourage the student to perform faster and faster until he has reached some predetermined level of proficiency. Skills which might be sharpened and improved by such devices include the interpretation of color codes, the accurate reading of meters, the use of a slide rule, and the reading of schematics.

There is a need for hundreds of thousands of small pocket-size or highly portable teaching machines for use in connection with correspondence courses. Most people who sign up for such courses find it very difficult to maintain the motivation needed to persevere from one lesson to the next, and the use of programmed instruction will not only increase the comprehensibility of information presented by correspondence but should significantly increase the number of people who complete such courses, once begun. I have been preparing material covering the subject of instructional programming for non-psychologists (which might be presented by correspondence), and I find that even though this is an embryonic area, much of the material is amenable to one form of programming or another.

There is another reason why the need for specialized teaching devices will expand phenomenally. Up until now researchers in the area of programmed instruction have been almost entirely concerned with the teaching of what is called "verbal skills," such as the teaching of mathematics, languages, spelling, psychology, and statistics. The entire domain of teaching perceptual and motor skills is virtually virgin territory. Special devices will be required for the teaching of such perceptual skills as meter reading, scope reading, component and color code identification, and for the teaching of such motor skills as are involved in test equipment operation and in the operation and repair of complex electronic equipments. There is no reason why the electronic engineering laboratory cannot now have a separate teaching machine to teach the energizing, calibration, operation, and utilization of each standard piece of test equipment. Such devices can be built for a cost not exceeding that of a medium-priced oscilloscope. In the future prime contracts calling for the construction of complex missile systems, aircraft, and space vehicles will undoubtedly include requirements, not only for training aids and simulators, but for devices which will actually teach the operation and maintenance associated with these equipments. Intriguing possibilities will no doubt soon be available to engineers interested in the programming of instruction.

Once programmed instruction has been introduced into the curriculum students will be able to learn considerably more material in considerably less time. But when this happens, what will happen to the instructor? Will automation put the teacher out of a job? Certainly not. But it will change the nature of his work. The advent of automation will give him a breath of fresh air and a new dignity, because now, instead of standing in front of an apathetic group of students trying vainly to transmit information in an environment ill-suited to his purpose, he will take on the role of a consultant; he will become an expert who can give individual attention to those needing it. He will have time to explore with the brighter students the more intricate aspects of the subject matter, and he will have time to help the slower student master the required content. This is a "consummation devoutly to be wished" and is a state of affairs which the engineer, working hand in hand with the research psychologist, will help to bring about. And I, for one, can hardly wait.

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3. Abstracted from a program prepared by Robert Leaton.

PRELIMINARY STUDIES IN AUTOMATED TEACHING[1]

Robert F. Mager

Data collected during preliminary studies of two methods of automated teaching were presented, accompanied by a description of characteristics and programing procedures for each method.

Automated teaching methods provide several advantages unattainable in the traditional classroom; every student advances at his own pace, participates actively in the learning, is immediately informed (by the device) of the correctness of his responses, and is rewarded for correct responses. Techniques of instruction automation provide means for completing the information loop between instructor and learner by providing feedback from the learner to the "instructor," thus enabling the teaching device to modify its program so as to optimize each student's rate of progress.

One method described sequentially presents items of information and test to the learner so that facts and concepts are built up and solidified to any required degree of learning. Items are scaled in such small increments of difficulty that the learner predominately makes correct responses to the machine and is thus maximally rewarded.

Another method described presents information in such a way that the response of the learner directly determines the information to be presented next. This programing allows fast learners to move rapidly ahead unimpeded by unnecessary explanations, while slower learners are provided with as many *different* explanations and practice items as are called for by his responses to the device.

Results of preliminary studies of these methods of automating instruction are presented. Two "difficult" concepts encountered in freshman chemistry were automated and presented to a freshman class of chemistry students at a midwestern university. Data indicate the superiority of this instruction over standard classroom methods.

In another study concepts of semiconductor physics were programed into a teaching device. Two groups of Institute of Radio Engineer members unfamiliar with this content were given instruction, one group by traditional lecture and the other by teaching device. Results of this experiment were reported.

Finally, results of automated teaching of college algebra to 11- and 12-year-old students, were discussed.

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[1] This is a summary of a paper given at the national convention of IRE (Institute of Radio Engineers) in New York City, 1959.

DEVELOPING NEW INSTRUCTIONAL TECHNIQUES[1]

P.G. Whitmore

This paper describes research techniques dealing with the problems of specifying criteria of training, developing procedures for guiding and assessing learning during training, and engineering known principles of learning into the training context. The emphasis is on what should be learned and how it should be learned.

The phrase "instructional technique" defies precise definition. Most of us, for instance, have at one time or another been faced with the chore of learning to recite the 12 cranial nerves in order, and most of us have probably done so by first learning some mnemonic device, which in turn was acquired by rote memorization. The ability to recite the names of the 12 cranial nerves in order obviously constitutes the objective or criterion of this small training program. Does the term "instructional technique" refer to the employment of a mnemonic device, to the rote memorization of that device, to the establishing of associations between the ordered words in the mnemonic device and the names of the cranial nerves, or to all three? The referents for many of the words currently used to describe the training process are either not specified or poorly specified. Any research in this area consequently must begin with what might be termed an operational analysis of the training process itself.

This process might best be described as a series of behavioral acquisitions beginning with an already acquired repertoire of behaviors and terminating with the acquisition of a specified set of behaviors. The first problem that must be resolved during the construction of a training program is selecting and specifying the behaviors whose acquisition the student must be capable of demonstrating at the termination of the training process. This problem is akin to the traditional content derivation problem, but differs from it in one very important respect. In most content derivation studies, content has been derived and specified in terms of the stimuli to which the student is to be exposed during training. Our interest, however, is in specifying the *behaviors* the student must in fact acquire. The problem of deriving these behaviors from the job requirements in itself comprises a major research effort. It is a problem, however, which need not be resolved prior to the initiation of research on the training process itself. This is not true, however, of the problem of developing procedures for specifying behaviors. The requirements for specifying the objectives of training must take into account the purposes for which the objectives are to be used.

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[1] Paper for Symposium at annual meeting of Southwestern Psychological Association, Spring 1960.

One action that must invariably occur in the conduct of a training program is deciding which students are, and which are not, to be graduated from the program at its termination. Cureton (1) has pointed out that "the *de facto* aims of an educational program and of every part thereof consist of those acts on the basis of which the students and the program are in fact evaluated. If any stated aim is not analyzed into specific actions and those actions observed and scored and reported the statement is no more than empty verbiage."

Amplifying this point Ebel (2) has suggested operationally defining educational objectives in terms of an extended series of test problems *before curricula are designed*. In this connection it is interesting to note that Adkins (3) has broadly defined a test as "a means of drawing inferences about persons, based upon their responses to a sampling of a field of behavior." What we are seeking in this phase of the research is a means for specifying the procedure by which the terminal pass-fail decision in training is to be made. Ebel's suggestion of doing this by means of an extended series of test problems is not a wholly satisfactory solution, primarily because the development of an extended series of test problems can become an overly tedious process. For some training programs there may well be an almost infinite number of test problems possible.

On the other hand, a danger exists in not specifying the objectives in sufficiently precise terms. For instance, if one objective of a geography class is a statement that a student must "familiarize" himself with a map of the world, nothing has been said about the type of behavior that must be observed in order to conclude that this objective has or has not been met. Would such an objective require that the student be able to produce and label an outline map of the world from memory or would it simply require that he label certain geographical features on a map presented to him? In either case, what features must he be able to label—major land masses, oceans, rivers, lakes, countries, capitol cities, major cities, and so forth? There would be almost as many different interpretations of such an objective as there were instructors teaching the course. There can surely be no purpose in expending either time or energy in the derivation of objectives and content for training which are subject to such a varied number of interpretations. Such a procedure could lead only to capricious evaluation of student achievement.

Training objectives might better be stated in terms of a description of the population of problems from which any particular test is to be drawn. Cureton (1) lists five characteristics that should be specified in the definition of a to-be-measured function, that is, of a population of test problems, as follows:

(1) "The acts or operations of which it is composed;

(2) "The materials acted upon;

(3) "The situations in which these acts or operations properly take place;

(4) "The results of products of the act or operations, and

(5) "The particular aspects or features of the acts or of their results or products which are to be considered as germane to the function."

In addition, it will be necessary to specify the procedures for selecting problems and for scoring the test to be used in arriving at the pass-fail decision. What is desired is a procedure for specifying how a particular test should be built so that separate test constructors working independently can each construct a test that will lead to the same decision concerning the achievement of individual students.

Our second area of research is concerned with getting the student from his initial repertoire of behaviors to those specified in the training objectives. This gives rise to the problem of determining what other behaviors must be acquired by the student in getting from "here to there," and will include problems dealing with the derivation of mediating and transitional behaviors, hints and prompts, and various degrees of approximate criteria for use during each phase of training. The heart of this area of research, however, is the development of techniques for sequencing these behaviors for maximally effective and efficient acquisition.

Our third area of research will be concerned with establishing optimal conditions of practice for each of the various types of behaviors that must be acquired during training. Here we will be concerned with the engineering of what is known about learning into the training context. Current efforts in this area are being devoted to assessing and summarizing what in fact is known about learning at this time. One major problem that we are encountering is that of translating laboratory operations into applied operations. We are having to make many "best guesses" in order to adequately summarize the state of the learning science for training purposes; we hope to start checking on many of these "best guesses" in the near future in a series of small studies.

As a preview to conducting rigorous research in these areas, we have been doing some informal work in automated instruction. This has been done primarily to acquaint the research staff with some of the problems involved in programming and in applying learning principles in the training context. Members of the staff, both past and present, have constructed programs dealing with electrical switches, molar solutions, proportions, multiplications, division, powers of 10, simple equations, powers and roots, nomograms, and graphs.

Some of these programs employ alternative sequencing, although most of them are of the sequential type. We have also developed a device for teaching accurate reading of electronic meters. This device was developed primarily to provide our engineering staff with preliminary experience on the type of circuitry required by "teaching machines." The engineering staff is currently developing a more versatile device centering around a 16mm motion picture projector.

Plans for the near future call for the construction of a "learning laboratory" that will contain nine individual booths.

Thus, our research is, and will be, concerned with three related types of problems:

(1) Specifying the criterion of training.

(2) Developing procedures for guiding and assessing learning during training.

(3) Engineering known principles of learning into the training context.

Instead of seeking answers to the questions "What should be taught?" and "How should it be taught?", we are rather asking "What should be learned?" and "How should it be learned?" The latter questions place emphasis on the behaviors that are in fact to be acquired by the student during training and on the procedures he is to employ in acquiring them, rather than on the stimulus material that is to be presented to him; that is, the paraphernalia of instruction in the form of textual and lecture material, training aids, and so forth. The specification of these things is secondary to the specification of the behaviors that must actually be acquired by the student during training.

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2. Ebel, Robert L. "Obtaining and Reporting Evidence on Content Validity," *Educ. and Psychol. Measmt.*, vol. XVI, no. 3, 1956, pp. 269-282.

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THE EFFECTIVENESS AND IMPLEMENTATION OF INSTRUCTIONAL CLOSED-CIRCUIT TELEVISION

Staff Members of Division No. 5 (Air Defense)

A means for evaluating the applicability of television to Army training programs is given in this paper, which discusses factors involved in both the construction and management of training programs that the training agency should incorporate into its courses before considering the utilization of closed-circuit television.

This report has been prepared in response to a request from G-3, U.S. Army Air Defense Center, Fort Bliss, Texas, for "a study on television which will provide guidance on the effectiveness, recommended methods of implementation, etc., as related to television and its application to effective instruction." A study of this nature has already been conducted by the U.S. Naval Training Devices Center (NTDC).[1] This report essentially concurs with the NTDC recommendations and presents portions of their report. In addition, this report emphasizes the fact that the presentation of information constitutes only one of many aspects of the instructional process. These other aspects are listed and discussed in an Annex to this report.

Whether the employment of instructional closed-circuit television will improve the effectiveness of training is primarily a matter of the adequacy of the training against which it is compared. Closed-circuit television is not a remedy for *all* training ills. It is primarily a technique for making certain types of instructional material simultaneously available to large numbers of students. The Pennsylvania State University television research project,[2] for instance, concludes that: "A break-even point between conventional instruction (in groups of 45) and televised instruction was estimated to be about 200 students." This break-even point is based on the use of vidicon equipment which is less expensive than orthicon equipment.

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[1] *Instructional Television Research Reports*, Technical Report No. NAVTRADEVECEN 20-TV-4, NAVEXOS P-1544, U.S. Naval Training Devices Center, Port Washington, L.I., N.Y., June 1956.

[2] C.R. Carpenter, and L.P. Greenhill. *Instructional Television Research, REPORT NUMBER TWO: The Academic Years 1955-1956 and 1956-1957. An Investigation of Closed Circuit Television for Teaching University Courses*, Division of Academic Research and Services, Pennsylvania State University, University Park, Pennsylvania, Spring 1958.

The Naval Training Devices Center has prepared a checklist (Figure 1) for evaluating the applicability of television to Army training programs (Figures are in a group starting on page 22 of this paper.) Their report recommends that the checklist be used by a committee of three instructors in a local situation, and that these instructors be familiar with the training schedules of the organization concerned and know thoroughly the training situation of that organization with all its special problems. In using this checklist it is not necessary for the evaluators to be aware of the fact that their evaluation may determine whether or not a given course of instruction is to be presented via television. Before television should be considered as an alternative presentation media, however, the training agency should ensure that it has done everything possible to make its training programs maximally effective and efficient within their current procedures. When this is done, it may frequently be found that the original problem for which television was considered no longer exists.

An Annex to this report presents a listing and discussion of factors involved in both the construction and the management of training programs which a training agency should incorporate into its programs before considering the utilization of instructional closed-circuit television. A careful detailed analysis on the part of the training agency may indicate that its difficulties in training, including the existence of a large student population, can be solved more effectively by techniques other than closed-circuit television. For instance, a detailed analysis of the job requirements may show that a large amount of irrelevant material can be pared out of its training programs; this will shorten the training programs and consequently decrease the number of students per instructor. Perhaps improvement of the effectiveness of training will require more opportunity for the students to apply and practice the required skills and knowledges; in this case, closed-circuit television would be of no value. Analysis may show that the existing training programs cannot be determined to be effective because of inadequate evaluation procedures, or that its examinations either are not administered frequently enough or are not sufficiently realistic to pinpoint training problems.

The NTDC checklist is reproduced in Figure 1. Their report states:

> "In general, the greater the number of marks after (1), the greater the adaptability of the lesson to instruction by television. Marks after (2) either means that the lesson contains no advantage for television, or that presentation by television may even in some cases be contra-indicated "..." The criteria checklist is a general guide in early stages of experience of television as an instructional medium. From a list of subjects those with a high (1) count (favorable for TV) can be quickly selected and considered for television use, but the final decision to televise a lesson or not should be made by the local command on the basis of the local situation. Favorable rating of a lesson on the criteria checklist is not a mandate to televise but rather indicates feasibility".

Some of the items in this checklist deserve comment in addition to that contained in the NTDC report.

Item 1. Type of instruction. If instruction is being conducted in accordance with the Army Field Manual 21-6 it may be difficult to find lessons that are purely presentation and/or demonstration. In discussing the application of the stages of instruction FM 21-6 states:

> "The stages of instruction serve as a checklist for the instructor in choosing teaching procedures. Whenever practical he applies all 5 stages to each lesson presented. It is often better to present certain subjects in small segments processing each segment through all the stages of instruction including the application and examination stages before going to the next segment. . . . In controlled practice, when material is presented step-by-step, the presentation and application stages are combined. Flexibility is the key to successful use of the stages of instruction". . . . "However, the instructor must study every instructional situation for opportunities to secure student participation in the application, examination and critique stages. He must strive for the complete teaching process in which he can plan, tell, show, do, check and review and/or critique".

Item 6. Supply of Training Aids. Currently used training aids may be in short supply because of their cost and/or complexity. Careful consideration should be given to whether or not such aids can be simplified and made less costly. Some evaluation should also be made as to their effectiveness in training. Only those training aids which are in short supply, whose training effectiveness and efficiency have been demonstrated, and which cannot be made either less costly or less complex should be considered in deciding whether or not a given lesson should or should not be given via closed circuit television. Figure 2 gives a list of training aids.

Item 7. Portability of Training Aids. The portability of training aids is not a problem if students can be readily brought to the aid rather than the aid to the students. The definition of "readily," however, will vary from one specific instance to another depending upon the mode and availability of transportation, weather, number of students per class, parking facilities, and so forth.

Item 8. Viewing Training Aids. Currently used aids may not always be the most appropriate. Many graphic aids, for instance, could easily be reproduced in student manuals, thus providing the student with whatever detail he may need and making the aid available to him for out-of-class study.

One other rationale frequently given for employing instructional closed-circuit TV is that it makes the best instructors available to a greater number of students. An extensive study conducted by the Air Force Personnel and Training Research Center,[1] however, indicates that there are no reliable and valid techniques currently available for identifying effective instructors, where effectiveness is defined in terms of student learning.

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[1] J.E. Morsh, and E.W. Wilder. *Identifying the Effective Instructor: A Review of the Quantitative Studies, 1900-1952,* Air Force Personnel and Training Research Center, Lackland Air Force Base, San Antonio, Texas.

In addition, it is interesting to note that in the Pennsylvania State University studies a hypothesis for future experimentation is formulated to the effect that methods of instruction are relatively unimportant. They are, however, using the phrase "methods of instruction" to mean "methods of presentation." Instruction would also include such factors as application and practice on the part of the student, and examination and review. This report points out that "two . . . potent factors are likely to be (a) repetition of the presentation of important concepts and (b) logical progression from one topic to the next."

If a training agency does decide to install instructional closed-circuit television equipment (i.e., if it finds that it has 200 or more students at the same point in training at a given time in a relatively substantial proportion of its courses; if it finds that its overloaded courses contain a substantial proportion of whole classes which are of a presentation and/or demonstration type, and if it finds that it has a shortage of instructors, equipment or facilities), then it should give careful consideration to how it utilizes its television equipment. The NTDC report lists some principles to guide the utilization of instructional television. These are reproduced in Figure 3.

Item 1 states the *maximum* number of students that should be allowed to view a single receiver. There may be some applications, however, in which this number should be reduced. Item 6 in this list has already been commented upon. With respect to Item 8 on the use of an intercommunicating system, it should be noted that the Pennsylvania State University studies found no advantage in such use. The Annex contains some further amplification of this point. The studio panel mentioned in Item 7 is strictly a matter of instructor choice. In several studies it has been indicated that instructors frequently prefer to have a studio panel available during their early television experiences, but that as the instructor becomes more adept and proficient in his television presentations, he generally no longer feels the need for a studio panel. The Annex contains some further guidance as to the use of in-course achievement tests which are mentioned in Item 9 of Figure 3. In a training situation achievement tests should be based not upon the curricula but rather upon the objectives of the training program.

Figure 2 presents the NTDC recommendations with respect to the use of training aids in instructional television. In constructing training aids to be used with black and white television, primary consideration should be given to the brightness rather than the color characteristics of the aid, since it is the brightness characteristics which will be reproduced at the receiver.

Figure 4 presents the NTDC recommendations with respect to television equipment.

Figure 5 gives the NTDC recommendations with respect to television operational techniques. With regard to Item 1 in this list, in those instances in which students are expected to take notes or to copy diagrams, drawings, outlines, and so forth, care should be taken to ensure that the material is kept on camera long enough for the student to do so and that other material not be presented during this time, that is, the instructor not continue lecturing during these pauses in the television presentation. In general, effective television instructional practices differ considerably from commercial practices. The instructional presentation should specifically avoid unnecessary or irrelevant camera motion, dramatic effects, unusual lighting, and in general the "slickness" associated with commercial productions. These things do not add to the instructional value of the presentation. It is much more important for instructional purposes to present the appropriate information in an instructionally effective manner and sequence and in a style characterized primarily by its clarity and containing as few distracting characteristics as possible.

SUMMARY AND CONCLUSIONS

This report, prepared in response to a request from G-3, U.S. Army Air Defense Center, Fort Bliss, Texas, for "a study on television which will provide guidance on the effectiveness, recommended methods of implementation, etc., as related to television and its application to effective instruction," essentially concurs with a study conducted by the U.S. Naval Training Devices Center.

The following conclusions are presented:

(1) Closed circuit television is not a remedy for all training ills. It is primarily a technique for making certain types of instructional material simultaneously available to large numbers of students.

(2) The checklist shown in Figure 1 is recommended for evaluating the applicability of television to Army training programs.

(3) Before considering television as a means of presenting material, other factors affecting the value of training programs should be considered. The Annex presents a listing and discussion of factors involved in both the construction and management of training programs which the training agency should incorporate into its courses before considering the utilization of closed circuit television.

(4) Principles to guide the use of instructional television are presented in Figure 2.

(5) NTDC recommendations with respect to the use of training aids with television are presented in Figure 3.

(6) Figure 4 presents NTDC recommendations concerning television equipment.

(7) Figure 5 presents NTDC recommendations concerning television operational techniques.

Checklist for
Evaluation of Army Training Subjects

Lesson____ Date____________________
(write in if not already filled)

Make a check mark for every item below according to your information or best judgment.

Think of the lesson in terms of a specific 50-minute period.

1. Type of Instruction
   (1) Presentation and/or demonstration. . ________ (2) Application . . ________
   (Mostly observation by trainee) (Training by doing)
2. Instructor-student intercommunication (two-way conversation)
   (1) Not necessary. . . . . ________ (2) Necessary . . . ________
3. Rapid dissemination of information (reaching many men early in the training or rapidly distributing new information)
   (1) Necessary (urgent) . . . . ________ (2) Not urgent. . . ________
4. Potential supply of instructors due to difficulty of subject matter (difficult, usually a shortage; easy, many available)
   (1) Few. . . . . ________ (2) Many. . . . . . ________
5. Physical risks (danger in the training situation)
   (1) Great. . . . . ________ (2) Little. . . . . ________
6. Supply of training aids
   (1) Short (more needed). . . . . ________ (2) Sufficient or plentiful . . . ________
7. Portability of training aids
   (1) Difficult. . . . . ________ (2) Easily moved. . ________
   (large, heavy, unwieldy) (light, easily handled)
8. Viewing training aids
   (1) Close-up necessary . . . . ________ (2) Close-up not necessary . . . ________
9. Color used in training aids
   (2) Color essential for teaching . . . . ________ (1) Not needed, unimportant . . . ________
10. Making a sound-film record
    (1) Highly desirable . . . . ________ (2) Not desired . . ________
11. Training time lost, moving from area to area
    (1) Much . . . . ________ (2) Little. . . . . ________
12. Does weather interfere with instruction?
    (1) Yes. . . . . ________ (2) No. . . . . . . ________
13. Security classification?
    (1) Unclassified or restricted . . . . . ________ (2) Confidential, secret, top secret. . . ________

Figure 1

NTDC Recommendations With Respect to the Use of Television Training Aids

It is recommended that:

1. Fine-lined schematics of letter size, 8½ x 11, be televised in the usual printing of black on white instead of reverse typography.
2. Large charts be made in contrasting shades of gray; gray on medium-brown background if possible.
3. Flannel-graphs, magnetic boards, and sectional flip-cards be used to economize time and to increase trainee attentiveness.
4. Soft, white chalk be used on a blackboard; yellow chalk on a green board given preference when available.
5. Models, mock-ups, cut-aways, and training boards to be used but that original equipment be substituted whenever possible because magnification can be produced by television.
6. Attention be given to colors and gray-values; that re-painting be done where shown to be needed by actual try-out.

Figure 2

Utilization of Instructional Television in Army Teaching

It is recommended that:

1. The number of students viewing one television receiver screen be limited to 20.
2. Television instruction be limited to four hours per day; each continuous viewing session to not more than 30 minutes; and that there be provision in the schedule for intensive discussion daily.
3. Television subjects be taught as an integral part of the curriculum with changes kept to a minimum.
4. Instruction be informal and extemporaneous.
5. The training situation be instructor-dominated.
6. The best available instructor be used for television.
7. A panel of three men be used in the studio if a partial substitute for class discussion is desired.
8. Each local training command decide whether or not to use an intercommunicating system.
9. There be achievement testing of the type usually employed.
10. Instructors thoroughly familiar with their subject matter and experienced in teaching procedures be selected for television and given some practice "dry runs".
11. Actual demonstrations supported by visual aids be presented on television.
12. Attitudinal subject matter as well as technical be televised.
13. The field use of television be given experimental consideration.

Figure 3

NTDC Recommendations Concerning Television Equipment

It is recommended that:

1. The inexpensive but effective lapel microphone be used.
2. Two cameras be provided in the studio but that it be kept in mind a satisfactory job of teaching can be done with one camera in case the other has failed.
3. A large studio monitor, properly placed, be provided so that the instructor can readily observe his own teaching.
4. Fluorescent lighting be used in the studio with portable floodlights on training aids when needed.
5. Lighting in classrooms be practically normal, avoiding reflections by the television receiver screen.
6. In mass teaching, intercommunication be provided only where deemed indispensable, to be determined by local command.
7. A large size television receiver screen, 19 inches or larger, be used in the classroom.
8. Large screen television projectors not be used.
9. Simple, inexpensive tripod camera dollies be used.
10. Distractions due to "burning-in" effects on tubes be avoided by proper manipulation of studio equipment.
11. Proper card stands, holders and other display devices be provided.
12. Television projection equipment be provided for the showing of films, film strips, slides and kinescope recordings.
13. The possibility of producing kinescope recordings be given serious consideration.
14. A closed circuit be considered standard but a supplementary open-circuit added where local requirements are deemed to make it highly desirable.

Figure 4

NTDC Recommendations Concerning Television Operational Techniques

It is recommended that:

1. Diagrams and drawings be kept compact on a blackboard, that the amount of writing be somewhat restricted, and the rate of writing deliberate.
2. Close-up shots be used liberally.
3. Super-impositions be used where it is desired to show relationships.
4. Fades and dissolves be employed as transitional techniques but that they should be used sparingly.
5. An occasional panning of the camera be used for spatial orientation and to provide a panoramic effect.
6. Whenever a subjective presentation is an advantage that over-the-shoulder (zero angle) shots be used.
7. Studio settings be simple ("quiet") to avoid the distractions of a complex ("noisy") setting.
8. A lesson be instructor-dominated and remain essentially so when two cameras are used.

Figure 5

ANNEX

Factors To Be Considered in Training Programs

The instructional process consists of two basic facets:

(1) The presentation of information to the student by an instructor or instructional device.
(2) The learning of new knowledges and skills by the student.

In constructing and administering a training program, emphasis should be put upon the learning of knowledges and skills by the student which should, in turn, determine the types of informational presentation to be made to the student. The first step in the construction of any training program is that of specifying the knowledges and skills that the student will be required to learn as determined by the requirements for the job for which training is being instituted. The second step is that of determining the sequence in which these knowledges and skills may be most efficiently learned. Learning invariably requires practice of that which is to be learned. Thus, the third step is that of determining the optimum conditions of practice for each of the knowledges and skills which the student must learn. The fourth step is that of determining the optimum type of informational presentation to make to the student in order to obtain the desired learning of knowledges and skills in the appropriate sequence under optimum conditions of practice.

Flexibility should be a part of every training program. Even though students are relatively homogeneous with respect to educational background and relevant aptitudes, these indices are not sufficiently precise to rule out all relevant differences between students or groups of students. Deviations from the initial instructional plan should be provided for and should be based upon the actual amount and quality of learning encompassed by the student.

In order to effectively implement the instructional process, the training program should include the following operational techniques and procedures:

1. The Specification of Training Objectives

The first problem which must be resolved by a training agency is that of deciding which knowledges and skills must, in fact, be learned by a student in order to perform adequately on the job. The solution to this problem must invariably be based upon a detailed analysis of the performances actually required by the job; i.e., a detailed task analysis. This is probably the most crucial step in the construction of any training program since errors in this step quickly become compounded in all other steps.

If relevant skills and knowledges are excluded from the statement of training objectives, training cannot possibly produce adequate job performance. If a substantial proportion of irrelevant skills and knowledges are included in the training objectives, job performance may be degraded and the cost of training will certainly be unnecessarily high. The exclusion of relevant skills and knowledges is probably the more damaging alternative. There is little point in expending training time without turning out a usable product.

Responsible training agencies must invariably be faced with the problem of deciding at the termination of training which students have, in fact, learned the knowledges and skills specified by the training objectives and which have not. The results of the major examinations employed during training and at its termination, constitute the basis upon which this decision is based. Thus the statement of training objectives not only specifies the knowledges and skills which the student must learn during training but also provides a basis for the construction of achievement tests for determining whether or not such learning has actually taken place. Achievement tests should be built specifically to assess the stated objectives of training. The items in such tests should be selected on the basis of their congruity with the knowledges and skills specified in the statement of training objectives rather than on the basis of their difficulty or homogeneity for any given population of students.

The statistical characteristics of test items are largely a function of the quality and character of the instruction. Ideally successful training programs should produce students, all of whom make the maximum possible score on the program's examinations. This, of course, is not possible in the practical situation but it should be maintained by trainers as a model towards which to work. Instruction is effective only to the extent that *appropriate* learning occurs.

2. Sequencing[1]

The knowledges and skills which the student is required to learn should be sequenced in such a manner that for any given point in training the student will have been provided with all the necessary background information (i.e., knowledges and skills) in the preceding phases of training. In order to make the student's learning more meaningful to him at each point in training and to maximally facilitate the integration of the knowledges and skills he is required to learn, the sequence in which he learns these knowledges and skills should generally follow a whole-to-part order. In addition, the skills and knowledges should be sequenced so as to discourage erroneous learning. Erroneous learning is wasteful of training time.

3. Conditions of Practice and Feedback

In order for learning to occur, that which is to be learned must be practiced. Passive receiving of information on the part of the student is inadequate for maximally effective learning. Much of the student's practice may be in terms of "thinking" during lecture presentations. In addition, much of it may occur during out-of-class study.

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[1] George H. Brown, Wesley C. Zaynor, Alvin J. Bernstein, Harry A. Shoemaker, *Development and Evaluation of an Improved Field Radio Repair Course*, Appendix A, HumRRO Technical Report 58, September 1959.

Neither of these kinds of practice, however, can be readily observed by the instructor. Thus, he cannot be assured that his students are, in fact, learning skills and knowledges required by the training objectives. Consequently, if he does not frequently check upon the progress of his students, he may fail to correct the defects in his instructional presentations until it is administratively too late to take appropriate remedial action. He may check upon student progress by allowing his students a brief period during which they may ask questions, by discussion, by his asking questions of a few students or by administering short quizzes during each instructional period.

Free questioning or undirected discussions on the part of the students as a primary basis for remedial action tends to be too inefficient and places too much responsibility upon the student for knowing what constitutes a relevant question. Spot checking of a few students may not always give an accurate picture of the achievement of the whole class, particularly if the class is large. Brief quizzes avoid both of these difficulties. The instructor is in a much better position to know what specific points in a presentation are of greatest relevance than are the students, and a quiz will provide him with information about the achievement of all his students.

The instructor has some latitude in selecting the point in training at which he chooses to evaluate the effectiveness of a particular hour or topical unit on instruction. He may give a short quiz either at the end of an hour of instruction or at the beginning of the next hour of instruction, which will generally be on the following day. Rarely can an instructor expect his students to learn the skills and knowledges specified for an hour of instruction purely as a function of his instructional presentation alone. Thus, if he quizzes at the end of the hour of instruction, he should restrict his items to those assessing skills and knowledges which the student might reasonably be expected to learn as a function of that hour of instruction without any additional practice. This procedure provides him with more time in which to consider the type of remedial action he might take if the results of the quiz indicate that adequate learning has not occurred.

If he quizzes at the beginning of the following hour of instruction, he can probably employ more adequate test items since he will be able to assume some practice beyond that given during the instruction itself. This procedure, however, requires that the instructor be informed about the student's performance on the quiz within a matter of minutes and that he can decide what remedial action is necessary and put it into effect immediately. It should be noted that any training program which takes a need for remedial action during training into account must also provide for instructor continuity over at least several successive hours of instruction. Otherwise, the instructor would have no opportunity in which to take the indicated remedial action.

Since a great deal of the student's practice may occur outside of the classroom, the instructor should also employ techniques for preventing erroneous learning and practice when the student is out of his direct control. He may attempt to do this by urging his students to take careful notes during his lectures and use the notes as a means of guiding their out-of-class study. He would be hard pressed, however, to actually insure that the students' note-taking in itself was accurate.

There are two practical alternatives open to him. First, he might write crucial information on the blackboard as he lectures. Since he will probably also want his students to carefully follow his lecture presentation as he gives it, and since note-taking frequently interferes with the students' attending, the instructor should pause sufficiently often to allow the student to copy the material on the blackboard and thus reduce the interference which might otherwise arise as a result of the student's attempting to do two things at the same time (i.e., attend to the lecture presentation and take notes). Secondly, the instructor may give each student a reproduced set of pre-prepared lecture notes and thus completely do away with the necessity of the students' taking any notes at all.

4. Methods of Presentation

The instructor who does not employ techniques for finding out what knowledges and skills the students are in fact learning as a function of his instructional presentation is not teaching but only submitting his students to auditory or visual bombast. In comparing one method of instructional presentation with another, it is necessary to take into consideration the practice conditions used in conjunction with each method of presentation. As one learning theorist has pointed out:[1] "A student does not learn what was in a lecture or book. He learns only what a lecture or book causes him to do".

Thus, the problem of selecting a method for presenting instructional information is essentially one of selecting a presentation which will induce the student to "do" those things which he is to learn. This is true not only in selecting a general method of presentation for a particular unit of instruction, but also in selecting training aids and devices. Emphasis should be on selecting aids and devices which induce the student to "do" those things which he is to learn. For instance, if a student is working with a special skill trainer, the trainer needs to resemble the equipment which the student will later use on the job only to the extent that it will induce the same response from the student as does the actual equipment.

Care should be taken to insure that informational presentations are not too long or complex to provide adequate control over the students' practice and application. Information in the initial phases of a long, complex presentation may well be forgotten by the student before the presentation is complete. For this reason Field Manual 21-6 recommends that ". . . it is often better to present certain subjects in small segments, processing each segment through

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[1] E.R. Guthrie, paper presented at meetings of the American Educational Research Association, February 1959.

all the stages of instruction, including the application and examination stages, before going to the next segment."

Care should also be taken to ensure that the method of presentation selected for a particular phase of instruction can in fact be implemented within the local training situation. For instance, the so-called "conference method" specifically attempts to establish classroom interchange between student and instructor. But it requires an instructor of such rare competence, experience, and talent as to be impractical for large training efforts. It almost invariably deteriorates into ordinary lecture presentations.

AUTOMATED INSTRUCTIONAL METHODS FOR TECHNICAL TRAINING[1]

Paul G. Whitmore

This paper explains attempts to obtain a basis on which to estimate the scope of applicability of automated instructional techniques to Army technical training. Experiments, training procedures, and problems are described and illustrated.

The training of men for combat effectiveness has traditionally been one of the major functions performed by an army. An army is not simply an accumulation of men, but rather an accumulation of men possessing knowledges and skills pertinent to the organization's combat effectiveness. The number and complexity of these knowledges and skills and their availability among current and potential U.S. Army personnel are the main factors determining the magnitude and scope of the Army's training effort.

The development of complex weapon systems has increased and is continuing to increase the knowledge and skill requirements which must be met by Army personnel. Men possessing appropriate technical knowledges and skills are not available in sufficient numbers in the general population. Therefore, the Army must conduct an extensive training effort in order to obtain technically qualified personnel. Such training is both costly and time consuming. An ever-increasing portion of soldier enlistments is being consumed by this necessary training, thus leaving less time available for the conduct of military duties. Consequently, it is necessary that the Army be provided with more efficient training procedures in order to arrest, and possibly even reverse, this trend.

The objective of research under Work Unit TEXTRUCT is to develop more efficient and effective instructional methods applicable to Army technical training. The first part of the research was devoted to the conduct of literature reviews and informal studies as a means of identifying and defining the research problems for future research.

Early efforts were concerned with exploring methods for improving group instruction. It was felt that the efficiency of group instruction might be improved by providing the instructor with means for obtaining information from his students concerning the degree to which they were able to understand all of his presentation while he was lecturing. A simple device was developed for obtaining and presenting this information. It consisted of a hospital bell-push switch of each of 10 response stations, a linear DC amplifier, and a sumnating meter. Several lectures on a variety of subjects were presented to audiences of unit personnel. Audience responses to these lectures were recorded on a moving paper tape. The audience members were requested to depress their bell-push switches whenever the lecturer's presentation became difficult to follow or understand. The lecturers agreed that for the most part audience response came too late for them to know with sufficient precision what part of the lecture had not been adequately understood. Audience reaction was simply not fast enough.

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[1] A briefing developed for presentation in December 1960.

Studies conducted at other laboratories using similar devices have found that instructors generally consider such devices to be too cumbersome for effective use. Certainly the ability to instantaneously vary a lecture presentation in response to audience reaction requires considerable skill and mastery on the part of the instructor. Additional studies of group instructional methods were not conducted since it was the opinion of the research staff at this time that large gains in instructional effectiveness and efficiency were not to be made in the group situation.

The decision to abandon the group situation and instead concentrate almost exclusively on the individual situation was largely predicated on the highly promising results obtained by researchers at other laboratories with automated instruction or "teaching machines." For instance, in one study a reading capability of German equivalent to one semester of college work was obtained in a mean total time of 47½ hours. In another study a one-semester college algebra course was taught in a mean total time of 30 hours. A conservative estimate would indicate that college students spend at least 75 hours total time in a one-semester course taught by traditional methods. Thus, in these two instances the use of automated techniques led to a savings in time of from one-third to better than one-half.

In a third study in which automated instructional techniques were applied to an introductory college psychology course, the median score on the final examination was 94%, and no student scored less than 85%. Previously, using traditional instruction methods only the very rare student scored as high as 85% on the examination. Automated techniques have been used for teaching second- and sixth-grade spelling, second-grade arithmetic, introductory college statistics, binary arithmetic, English grammar, introductory college physics, symbolic logic, and electronics troubleshooting. Thus, it would appear that these techniques not only offer great promise but also have a wide range of applicability.

Automated instruction is primarily concerned with engineering into the instructional situation four important learning principles which are not generally accounted for by traditional instructional methods. These four principles are:

(1) Continuous participation by the student in the instructional process.

(2) Providing immediate knowledge of results to the student for each response that he makes.

(3) Recognition of individual differences in rate of learning.

(4) Providing a high rate of success for the student throughout learning.

Let us consider how these principles are actually applied in the construction of an automated program. For example, in one of a series of programs each page can present the student with a small amount of information and require that the student in turn respond to each page. In this way the program requires continuous participation on the part of the student. On the back of each page is the correct answer which the student should have given, thus providing him with immediate knowledge of results. Since the program provides individual instruction, it allows each student to proceed at his own rate and thus accounts for individual differences in *rate* of learning.

The most difficult principle to implement is that of providing the student with a high rate of reinforcement or success throughout learning. Ideally, we would like to have programs by which students could learn without making a single mistake. To build a program that even approximates this ideal requires intensive analysis of material to be learned, plus several carefully conducted tryouts of provisional programs. The primary problems are concerned with appropriately fractionating or segmenting and sequencing the material. Basically two different methods of sequencing have been proposed. B.F. Skinner of Harvard University introduced the sequential method in which every student proceeds by the same route through every step in the program. He is more or less forced to employ sequential programming by his theoretical bias favoring constructed responses. Norman Crowder of Western Design, Inc., developed the alternative method of programming in which different students proceed by different routes through varying steps. This flexibility is made possible as a consequence of employing response selection instead of response construction; that is, the alternative method employs multiple-choice type items in each step. The alternative method shows promise in being able to account not only for individual differences in rate of learning, but also for differences in aptitudes and in previous achievement.

In order to become familiar with the problems involved in building these types of instructional programs, members of the research staff built several on various topics which were presented in book form. The first two of these programs—molar solutions and electrical switches—were not intended for operational use. However, at the request of the Air Defense School, the staff built a series of nine programs to be used by applicants to the Air Defense Missile Officer Basic Course as a means of correcting deficiencies in mathematics knowledge prerequisite to the course. These programs provide instruction on multiplication and division of decimals, cancellation, powers and roots, powers of 10, logarithms, proportions, stated algebraic problems, reading nomograms, and reading graphs. These programs have been informally administered to a variety of individuals including Army officers and enlisted men, civilian employees, and college students.

In addition, a college freshman algebra program developed by Gilbert at another laboratory was administered to a few teen-age and near-teen-age children of the staff and some of their neighbors. Since these programs are all concerned with verbal and symbolic material, an experimental device for teaching a perceptual skill was also constructed and tested. This device was designed to teach the ability to read a meter, but proved to be a dismal failure for its intended use. However, it did teach the research staff a considerable amount about the requirements for designing and constructing such devices. Although these experiments were extremely informal, they did provide the kind of initial guidance necessary for the planning of a research program.

It readily became apparent that because of the precise control over the instructional process afforded by these automated techniques, it is necessary to specify the objectives and achievement prerequisites of an automated program in minute detail before a program can be built. This difficulty was most pronounced during the construction of the graph reading program and was probably due to the fact that graph reading is usually not taught as such or is not taught at all. Consequently, there was no core of implicit detailed objectives available to the program writer. Although a set of general objectives had been prepared in advance, they were found to provide an inadequate basis for the many decisions required during the construction of the program. What originally appeared to be an adequately stated objective was found still to contain too many alternatives from which the program writer might choose. To have included all possible alternative objectives would have resulted in a large, unwieldy, unusable program and would have required too much time for its development.

The segmentation or fractionation of the course content deemed the most rational or logical to the program writer or subject matter expert may not, and probably will not, be the most adequate for instructing naive students. In obtaining the coordinates of a point on a graph, for instance, instruction should teach the student to move from the given point to the axes, rather than from the origin along the axes to the point; that is, it is necessary to distinguish between the act of reading a graph and the act of constructing a graph. In preparing the program on molar solutions, it was found necessary to distinguish the act of determining the amount of solute present in a solution of known molarity from the act of determining the amount of solute needed in order to prepare a solution of given molarity; that is, it was necessary to distinguish the act of analysis from the act of synthesis. A subject matter expert may frequently fail to make such fine distinctions between the various directions in which relationships may exist or may fail to adequately identify the behavioral elements of an act relevant to its instruction.

In several instances, students complained that the automated material was too easy, although the same material presented by traditional methods has been among the more difficult topics in the course. One of the children to whom Gilbert's algebra program was administered easily completed the first two lessons successfully then lost interest in the program. Several of the college students who tried the program on molar solutions complained of its being too easy, although they did complete the program. Dr. Jesse Day, chairman of the Chemistry Department of Ohio University, tried the molar solution program in some of his freshman classes and was so gratified with the results that he programmed the kinetic theory of gases for juniors in his physical chemistry class. Again his students learned the material better than they ever had by conventional methods, but this time he received severe complaints about the program's being too easy. Questioning brought out the fact that the wives of some of the students had worked through their husbands' programs, learned the material, and were unable to understand why their husbands complained about the difficulty of the course.

It further appears that even with these techniques, special attention must be given to the problem of obtaining adequate retention over long periods of time. It is possible for students to work through these programs successfully and still not retain the material any better than they would by conventional methods. Immediate retention within the context of the program may carry a student through the program with little or no difficulty, but yet not insure the permanency of the learning. This is a problem easily overlooked in program construction and essentially requires that long-range retention be handled as a problem separate from immediate understanding.

This first effort has identified certain researchable problems concerned with the derivation and specification of training objectives and prerequisites, with the fractionation and sequencing of training content, and with the retention of learned material over time. One of the major problems in the area of training, however, is that of relating the many factors which go into the instruction and administration of a course into some coherent whole. Since the interrelationship of these factors has not been established at this time, it is not possible to begin separate research projects on each. Rather, it is first necessary to generate an approximate solution for the whole to provide guidance concerning their interrelationship.

Problems that need to be explored relatively soon are those incident to the construction and management of a fairly long, heterogeneous, largely automated instructional program. It is necessary to obtain some realistic basis on which to estimate the scope of applicability of automated instructional techniques to Army technical training and on which to estimate the general organizational and administrative policies that may be required in order to effectively implement automated instructional techniques on a large scale.

Tentative answers are needed to such questions as:

(1) What kind and how many of the Army's training requirements are amenable to automated instructional techniques?
(2) What kind of instructors or supervisors would be required for partially or fully automated courses?
(3) Can purely automated courses maintain active student interest over long periods of time?

(4) How can automated courses which emit students individually rather than in groups be meshed together into an integrated training program?

One vehicle which appears attractive as a context for such developmental research is basic electronics in which the content of the course consists of the skills and knowledges common to many specific electronics maintenance positions.

There are several reasons for choosing basic electronics as the content vehicle for such research. First, it would provide the heterogeneous content necessary for estimating the scope of applicability of automated instructional techniques to Army technical training. Second, such a course would be sufficiently long (at least several weeks) to entail most, if not all, of the construction and administrative problems that might arise in attempts to implement automated instructional techniques on an Army-wide basis, but not so long as to be prohibitive in terms of the amount of time that would be required to automate it. And, third, the development of an automated basic electronics course would be of direct value to the Army in that this specific content is important for so many Army jobs.

Certainly optimal solutions to all of the problems encountered during the course of such research could not be generated. However, even though the solutions which may be generated may not be optimal, they would at least not leave the problems completely unresolved and many of them would be quite applicable to training programs utilizing conventional instructional methods. Refinement of these solutions would in turn become the subject of future research efforts.

In order to meet these research requirements, a second project has been proposed and approved to determine the feasibility of automating a basic electronics course for use by the Air Defense School.

DERIVING AND SPECIFYING INSTRUCTIONAL OBJECTIVES[1]

P.G. Whitmore

This paper stresses the necessity for statements of instructional objectives in the construction of mass automated teaching programs, and also the need to develop rationales and procedures for contriving terminal behavior patterns. The efficiency of instructional control is also determined by the behavior capabilities of the student prior to instruction. An example of a verbal hierarchy is given.

GENERAL STEPS INVOLVED IN CONSTRUCTING MASS INSTRUCTIONAL PROGRAMS[1]

Let us look at a student in an instructional situation. We see a human organism engaged in the sporadic production of relatively discrete behaviors, as, for instance, practicing a perceptual-motor skill, reading a text, or writing. If we were actually to become the student (i.e., if we were to shift from external to introspective observation), we would become aware of a continuous stream of activity, consisting of both explicit and implicit behaviors. Instruction is concerned with the design and arrangement of situations to control this introspectively observable stream of behavior so as to modify it to conform to some predetermined pattern.

There are two things that need to be determined before such situations can be designed and arranged:

1. The behavior pattern the student should be capable of performing at the end of instruction.
2. The behavior capabilities possessed by the student before instruction begins that are relevant to the terminal behavior pattern.

These two behavior capabilities define the behavioral range of instructional concern. The maximum possible effectiveness of instruction is determined by the job validity of the terminal behavior pattern. The maximum possible efficiency of instructional control is determined by the degree of precision with which these two capabilities are specified.

A tentative and rough outline of the steps involved in the construction of an instructional program is presented in Figure 1. In general, each step consists of an analytic process, a specification of the products of the analysis, and a means for determining whether such products are adequate in terms of job-incumbent or student behavior.

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[1] Paper for Symposium, "Automated Teaching: Research Problems," American Psychological Association, New York City, September 1961.

These steps group themselves into three major phases. The first is concerned with identifying the terminal behavior pattern that the student actually needs to learn in order to perform the job adequately. The second phase is concerned with identifying transitional and supporting associations, and with the organization of the to-be-learned behaviors into optimum practice units arranged in some optimum sequence. The third phase is concerned with the design and arrangement of instructional situations, including the determination of response mode, type

General Steps in the Construction of Mass Instructional Programs

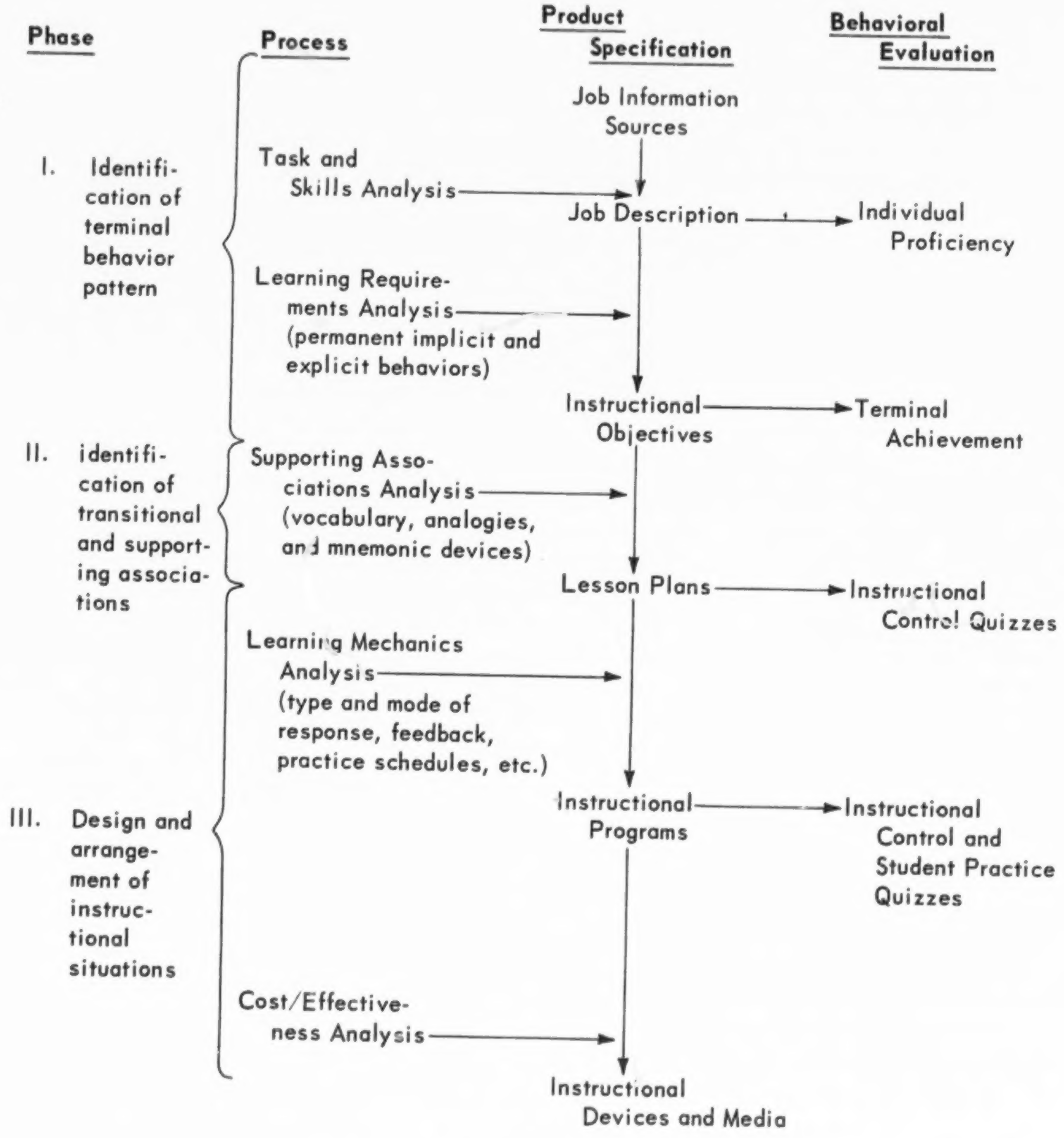

Phase
Process
Product Specification
Behavioral Evaluation
I. Identification of terminal behavior pattern
II. identification of transitional and supporting associations
III. Design and arrangement of instructional situations
Task and Skills Analysis
Learning Requirements Analysis (permanent implicit and explicit behaviors)
Supporting Associations Analysis (vocabulary, analogies, and mnemonic devices)
Learning Mechanics Analysis (type and mode of response, feedback, practice schedules, etc.)
Cost/Effectiveness Analysis
Job Information Sources
Job Description
Instructional Objectives
Lesson Plans
Instructional Programs
Instructional Devices and Media
Individual Proficiency
Terminal Achievement
Instructional Control Quizzes
Instructional Control and Student Practice Quizzes

Figure 1

of response, knowledge of results, and the design and integration of practice and review schedules.

DETERMINING WHAT THE STUDENT NEEDS TO LEARN AND RETAIN

The first phase in constructing an instructional program is directed toward identifying the behavioral range of instructional concern. This phase consists of two major steps:

1. Determining the behavioral skills required for effective job performance.
2. Determining the behaviors that the student needs to learn in order to produce the required job skills.

The former is specified in the job description and the latter in the statement of instructional objectives. The job description lays out the behavior pattern required for effective accomplishment of the job in terms of the effects, accomplishments, or goals of the behavior with respect to the job environment. A major effect or goal can usually be analyzed into a set of sub-effects or sub-goals, which may in turn be analyzed into sub-sub-effects or sub-sub-goals, and so forth. Thus, we will generally find a hierarchical organization or breakdown in descriptions of job skills.

The source from which information is obtained for generating the job description will vary widely depending largely upon factors of availability, time, and cost. Such information may be obtained by means of expert judgment or prediction, interviews and questionnaires, equipment analysis, gaming techniques, and so forth, and may or may not have been preceded by organization and position structuring activities.

The first step in deriving the statement of instructional objectives consists of preparing a description or set of instructions for performing the various job skills in sufficient detail to allow incoming students to perform the job activities, although not necessarily with the same speed and precision requirements placed on the job incumbent. This step essentially consists of a continuation of the breakdown or hierarchical analysis used in developing the job description. One major problem in this step, which also occurs in the development of the preceding job description, is that of selecting between alternative procedures for accomplishing the same effect or skill. In selecting one of several procedures as an instructional requirement, there are three general factors to be considered, job efficiency, ease of learning, and compatibility with related procedures.

Each of these factors is in itself rather complex and each needs to be considered in relation to the others. The matter of compatibility becomes especially important when we try to reduce to a minimum the number of new behaviors that the student will have to learn in order to be able to perform the job. I shall return to this factor.

This first step, that is, developing a description of the various job skills that can be understood by the incoming student, provides us with a verbal linkage between the student's pre-instruction repertory and the required job skills. Let us examine the nature of this verbal linkage and how it relates to the instructional process.

I am sure we will agree that in most instances students will need to learn considerably more than those behaviors that are available to external observation on the job. Generally, these additional behaviors are implicit verbal and symbolic behaviors that we infer occur on the job as a means of mediating the externally observable job behaviors. Simply granting that such implicit verbal behaviors are important to obtaining adequate job performance, tells us nothing about how to go about identifying them so that they can be described. In order to better understand *what* implicit verbal behaviors need to be described, we first have to challenge the basic notion that such behaviors are necessary in order to obtain adequate job performance.

How can we identify these implicit verbal behaviors? What are their essential characteristics? What role do they play in instruction and in job performance? The answers that we can obtain to these questions at this time are at best primitive. Let us begin by taking a close look at three hypothetical instructional situations.

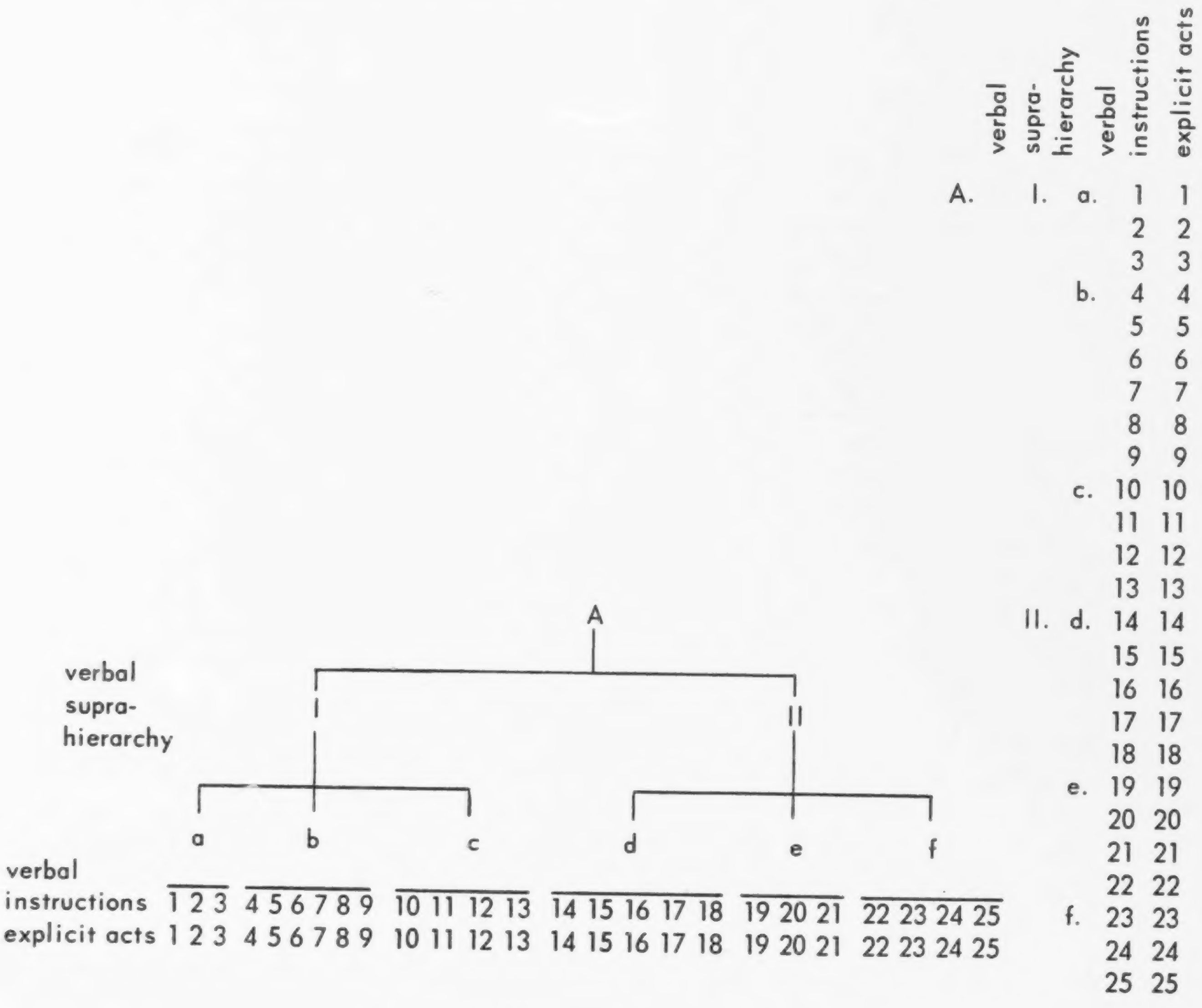
> *Situation 1—Non-verbal instruction.* In this situation the instructor demonstrates an activity to his students and the students then attempt to imitate the demonstration. Such demonstration-imitation trials continue successively until the students can perform the activity without error. Such a method is obviously slow and greatly restricts the number of students that one instructor can handle. To handle all the instruction for a complex job in this fashion would be far too costly and time-consuming.
>
> *Situation 2—Unlearned verbal instructions.* In this situation the instructor is allowed to communicate verbally with his students. He provides them with verbal instructions for performing each step of the activity. It would seem reasonable for him to begin with the demonstration of the activity, after which he would verbally lead the students through the activity step-by-step, giving the detailed verbal instructions for each step immediately before performing it. His objective, however, is to lead his students to be able to perform the activity without his continued verbal guidance. Thus, he would gradually withdraw this help from successive practice trials until the students could perform the activity correctly without any verbal guidance. In terms of instructional feasibility and economy, this situation constitutes an obvious improvement over the first.
>
> *Situation 3—Learned verbal instructions.* In this situation the instructor requires his students to learn the verbal instructions for performing the activity or part of the activity, and then to practice it by generating their own verbal instruction. This would appear to be the most advantageous instructional situation for imparting the great majority of skills that adolescents and adults may be required to learn. The movements and acts by which such skills are produced infrequently constitute *new* behaviors for the adult human. In addition, there are usually some verbal instructions available that can be used to elicit the movements and acts;

that is, they are generally under verbal control. Thus, the student may already possess the ability to produce the movements and acts as a consequence of verbal stimulation. If he is told what to do in sufficient detail, he can do it. Consequently, the major instructional problem will be that of having the student learn how to generate his own verbal stimulation or verbal instruction for correctly performing the skill.

DESIGNING VERBAL INSTRUCTIONS

Once we have made the decision to employ learned verbal instructions in the production of skill performance, there are certain factors we should take into account in designing the verbal instructions themselves. Let us consider a hypothetical example, schematized in Figure 2. Suppose we have an activity or skill consisting of a sequence of

Skeletal Organization for Learning Task


A
verbal supra-hierarchy
I
II
a
b
c
d
e
f
verbal instructions 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
explicit acts 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
verbal
supra-hierarchy
verbal instructions
explicit acts
A.
I.
a.
b.
c.
II.
d.
e.
f.

Hierarchical Form

Outline Form

Figure 2

25 steps. To train a student to learn and remember the verbal instructions for performing these steps in sequence without introducing any verbal behaviors other than those involved in telling him how to perform each one singly, will require considerable repetition. Such a procedure tends to restrict the cues for initiating a step to the termination of the preceding one and, at least during early learning, does not restrict errors between remote steps in the chain. For instance, the student might easily confuse the second step with the 18th one. The problem here is that the student has too many alternatives to remember in order to make a decision as to what to do next at any particular instant.

We can improve this situation by applying some notions borrowed from George A. Miller, Eugene Galanter, and Karl H. Pribram (1, 2, 3). First, we can contrive a verbal supra-hierarchy constructed so that each step contains some number of component steps less than seven. In this way we restrict the alternatives that a student needs to remember at any one instant to a number within the average span of immediate memory. Second, we design the step labels on entries in the hierarchy to be "rememberable." This implies that they should be short and bear some clear relation to the subsequent terms in the hierarchy.

If we now turn the hierarchical structure in Figure 2 on its side and slightly rearrange the terms without changing the relations between them, we see that what we have been doing is actually quite similar to old, familiar procedures for outlining.

One characteristic of a good textbook is that it explicitly lays out this kind of skeletal organization. In addition, we frequently find that the better students in a class will actually learn this skeletal organization and if it is not explicit in the text, better students will generally tend to make it explicit. This kind of organization of verbal material is not new—textbook writers, instructors, and students have been using it for centuries. I am simply attempting to state some of the reasons for organizing materials in this manner and the implications of these reasons upon how we do it, as a means of improving the organization of verbal material in our instructional programs. However, there are still many unresolved problems concerning the construction of such verbal hierarchies. The hypothetical example given is restricted to a single activity and for such single activities the construction of verbal hierarchies seems to be fairly straightforward. There are still some remaining questions concerning the degree to which we can build *similar* hierarchies for controlling the performance of several *similar* activities and thus reduce the amount of verbal material that the student will have to learn, and with the construction of such hierarchies for controlling the performance of activities that consist of complex *branching* chains containing many choice points—rather than simple linear chains as in the example.

Example 1

Rigging the VTVM

Legend

Major functions
- I. Ohms measurement
- II. AC voltage measurement
- III. Positive DC voltage measurement
- IV. Negative DC voltage measurement

A. Make INITIAL SETTINGS
- 1. Turn ON meter and position FUNCTION switch
  - a. PLUG in meter (AC LINE cord)
  - b. Position FUNCTION switch

major function	switch position
I	OHMS
II	AC VOLTS
III	+ DC VOLTS
IV	- DC VOLTS

  - c. Check to insure that red pilot LIGHT at top of meter turns ON
- 2. Select RANGE
  - a. Position RANGE switch
    - I - position RANGE switch to an OHMS position which places the anticipated reading near the center of the scale (between 10 and 100 on the OHMS scale). If approximate value is not available, position RANGE switch to RX1000 position.
    - II - position RANGE switch to highest AC setting (500 volts on this meter). If *certain* that reading will not be more than a given lower range, then that lower range can be used.
    - III & IV - position RANGE switch to highest DC volts RANGE (1000 volts DC only)
  - b. WARM UP
    - I, II, III & IV - allow 30 seconds for meter to warm up before proceeding. Needle will fluctuate while meter is warming up.
- 3. CALIBRATE METER
  - a. Select PROBES
    - I - OHMS (green) & COMMON (black)
    - II - AC (red) & COMMON (black)
    - III & IV - DC (black with large insulated probe) & COMMON (black)
  - b. INFINITY adjust
    - I - with the two probes not touching, adjust OHMS ADJ knob until meter needle is positioned exactly on infinity (oo) on OHMS scale
  - c. ZERO adjust
    - I, II, III, & IV - "short" probes (i.e., hold test probes tightly together) while adjusting ZERO ADJ knob until the meter needle is positioned exactly at zero (0) of appropriate scale
- 4. CHECK meter settings

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.

B. Connect PROBES

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C. READ meter scale

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.
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D. Determine if reading is in TOLERANCE

.
.
.

E. Turn OFF meter

SUMMARY AND CONCLUSIONS

Let me summarize the functions served by a statement of instructional objectives:

First, such statements should specify the explicit behaviors required by the job that students need to learn in order to perform it adequately. The identification of these behaviors frequently involves a complex and tedious procedure, but not one that is beyond ready comprehension—at least for jobs that are already in existence.

Second, such statements should specify the implicit verbal and symbolic behaviors contrived to mediate job performance, facilitate long-range retention, and, in many instances, make instruction practicable. The conduct of this step is much more difficult. We need to develop rationales and procedures for contriving various kinds of implicit behaviors. In addition, such procedures must lead to a minimum number of associations to produce a maximum effect. Although this is the area covered in this paper, the rationales underlying the example given are at best primitive and are restricted to but one kind of situation for which verbal mediation might be used; that is, a moderately long linear chain.

Third, statements of instructional objectives should specify the relevant characteristics of the instruments to be used in evaluating student achievement (4, 5). I have already mentioned the specification of the behaviors and behavioral associations that the student needs to learn and remember. In addition, it is necessary to specify the objects and the proper situations for each act or operation and the criteria of adequacy for each act or operation. Procedures for sampling content and for scoring should also be specified. What is desired here is a procedure for specifying how a particular test should be built so that separate test constructors working independently can each construct a test that will lead to the same decision concerning the achievement of individual students.

Traditional test construction rationales and procedures are not appropriate to a measurement of in-course achievement. Traditional procedures have been developed primarily for selection situations in which the primary problem is one of ordering individuals along some achievement dimension. In an instructional situation, however, our primary interest is in determining whether or not a *given* individual has attained a specified achievement criterion. The fact that some "passing" students learn more than other "passing" students is of little concern to us unless we are going to base some action on this difference. There is little point in differentiating between students unless they are to be treated differently.

What does all this have to do with automated teaching and programing? If you will look again at Figure 1, I think the answer will become apparent. Both the reinforcement and the communication models currently underlying the programing movement are primarily concerned with the mechanics of learning. Neither is particularly concerned with the design of the terminal behavior pattern or with the design

Example 2

I. The following items are to be answered in order with no retracing. All items must be answered correctly.

1. List in any order the four major functions for which a VTVM may be used.
   a. ohms measurement
   b. AC voltage measurement
   c. positive DC voltage measurement
   d. negative DC voltagement measurement
2. List in order the five common steps which need to be performed in order to use the VTVM for any of its major functions.
   a. make initial settings
   b. connect probes
   c. read meter scale
   d. determine if reading is in tolerance
   e. turn off meter
3. List in order the four common steps which need to be performed in order to make the initial settings for any of the major functions of the VTVM.
   a. turn on meter and position function switch
   b. select range
   c. calibrate meter
   d. check meter settings
4. List in order the three common steps which need to be performed in order to turn on the meter and position the FUNCTION switch.
   a. plug in the meter AC line cord
   b. position function switch
   c. check to insure that red pilot light at top of meter turns on
5. Match the following FUNCTION switch positions with the appropriate function.
   __ a. ohms measurement
   __ b. AC voltage measurement
   __ c. positive DC voltage measurement
   __ d. negative DC voltage measurement
   a. +DC VOLTS
   b. -DC VOLTS
   c. OHMS
   d. AC VOLTS

   c a.
   d b.
   a c.
   b d.

   .
   .
   .

of transitional and supporting associations. If these aspects of the process are not explicitly controlled, then they are passed by default to the whims of individual programers. Furthermore, the failure to develop specific rationales and procedures for these aspects of the process may well be one reason why programing is an expensive, time-consuming art form. The programer is left with the overwhelming problem of doing all of these steps simultaneously. Although every how-to-do-it article on programing that I have seen *starts* with an instruction to "define the objectives," I have yet to see one that tells exactly how to go about doing this.

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MILITARY CONTROL—A FREQUENTLY MISSED TRAINING OPPORTUNITY[1]

Robert G. Smith, Jr.

Advantages of military control in motivating students to be rapid learners in self-paced programmed instructional courses are discussed. Examples of techniques to control student learning behavior are given.

I am concerned by the theme of this symposium, and particularly by the preliminary material sent to participants. This material says in part: "The participants on this symposium will discuss how to cope with administrative problems sure to be generated by allowing trainees in closely scheduled training systems (most obviously, the military) to proceed at their own paces. What suggestions should be made to practical-minded commanders who find a lot of bright people on their hands, having completed an eight-week course in two weeks?"

The greatest disservice we can do to "practical-minded commanders" is to cut the heart out of one of the greatest advantages of programmed instruction. This advantage is the opportunity for the bright people to complete an eight-week course in two weeks. Instead of considering this a problem, let us consider it an opportunity—an opportunity for mobilizing military controls over students so as to motivate the best students to make the most rapid progress of which they are capable through the training program.

I would like to tell a story told to me several years ago by a pilot instructor during World War II. From his familiarity with flying students my instructor friend knew that the big event of the training program was the cross-country flight in which a considerable amount of freedom was given to the student to select his destination. My friend convinced his superiors to try a rather daring deviation from the usual training practice. He promised the students that if they reached the stage at which they were ready to go on their cross-country flight before a certain time (which was less than the usual time it took the students to be ready), then any time saved they could have as leave to take at the place to which they flew. He gave his students instruction in the use of mental practice and "turned them loose."

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[1] Paper for American Psychological Association Convention, New York City, September 1961, as part of a symposium, "Problems in Classroom and Institutional Management Created by Teaching Machines and Programmed Instructional Materials."

The result of this procedure was that the students were able to make their cross-country flights in a great deal less time than was the case in the regular instruction.

The story illustrates my theme very well. The military services typically exert a high degree of pervasive control over the behavior of their members. At the same time these control techniques are seldom mobilized on the side of training.

With conventional lock-step training procedures, there is often little gain for the better student if he progresses and learns more readily than the poorer one. But one of the principal characteristics of automated instruction is that it provides for the possibility of the better student's completing a program much sooner than the poorer student. Rather than discuss the *problems* created by this characteristic, I would prefer to discuss some of the *opportunities* that are now available to the military services if they will appropriately mobilize their controls to assist training programs.

All too frequently the various privileges that may be available to military personnel are not dispensed by the persons in charge of the training programs. Instead they are dispensed by someone else—a student detachment commander, whose functions are typically those of an administrator and housekeeper. Let's examine some of the possibilities that exist for mobilizing military controls in order to motivate students to progress through an individualized training program as rapidly as possible.

One of the standard military ways of rewarding good performance is the granting of a pass. In lock-step training programs students typically are not granted passes because of the problem created when students miss classes and need to "make them up." However, in an individualized training program a pass could be a worthwhile reward for a student who is making progress at a very rapid rate.

Another possibility exists in the matter of assignments. Normally, when a group of students is entered into a training program, there is also a group of assignments awaiting these students upon the completion of their training program. It appears to me that an excellent motivator to get people to complete a training program quickly would be to provide that personnel who complete the program will be given their choice of those assignments available at the time they finish. Thus, the person who finishes first can have his choice from among all the assignments that are available to his class. Those who finish later will find that the choicer assignments will have been taken by those people who got through earlier.

Another characteristic of the life of the typical student is that the military services tend to keep him occupied at some kind of activity all day long and often well into the night. As a result, the student seldom has free time to catch up on his sleep, or to take care of other kinds of personal needs. If he is making exceptionally rapid progress in the training program, he might be permitted to report to the classroom or to the place of instruction later, or to leave an hour or so earlier, than the rest of the students. This would give rapid learners an opportunity to get in a little extra sleep, to take care of personal business, or just to relax a little.

Another frequent characteristic of military training programs is the compulsory study hall. Students who are making exceptionally rapid progress through the course may well be excused from such study halls.

I think I have given enough examples of specific possibilities. I feel sure that ingenious training officials can think of a large number of ways that military controls could be used to support a training program. My main point, however, is that with lock-step training programs we could not effectively make use of these techniques for motivating students. But with training programs in which the student progresses at his own rate, the military services, through their control of student behavior, have a very significant opportunity to mobilize these controls in order to greatly assist their training programs.

A RATIONAL ANALYSIS OF THE PROCESS OF INSTRUCTION[1]

P.G. Whitmore

Summary—Instruction is defined as a process for controlling student behavior so as to insure student learning, rather than as a process for merely presenting information to students to learn in whatever way they can. Learning, in turn, is defined in terms of behavioral associationism. Thus, the problem of specifying an instructional program so as to lead to effective control of student learning as directly as possible is largely a problem of adequately describing the behaviors required of the student at specified points in the instructional program.

The main body of the paper is concerned with the general application of these basic definitions to the problems of:

(1) Identifying what it is that is to be learned,
(2) Sequencing the order in which instructional materials are to be presented,
(3) Designing instructional situations for accomplishing the desired learning.

Evaluation is defined as consisting of two major aspects:

(1) Evaluation of the effectiveness of the instruction for inculcating students with the behaviors selected for them to learn,
(2) Evaluation of the effectiveness of the behaviors selected for the student to learn for producing adequate job performance.

INTRODUCTION

The purpose of this paper is to provide the lay reader with a general understanding of the process of instruction, and an appreciation of the problem areas that must be resolved before we can claim to have a complete and adequate technology of instruction. The body of the paper is organized as follows:

I. *What is instruction?* This section presents a borrowed definition of learning and relates instruction to learning. Furthermore, it attempts to answer the question, How should instructional programs be specified? and draws a distinction between methods of instruction and methods of presenting information.

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[1] This article appeared in *IRE Transactions on Education,* December 1961, pp. 135-143.

II. *The major steps in the construction of mass instructional programs.* This section is concerned with the problems of:

  A. Identifying the material to be learned.
  B. Sequencing the order in which instructional materials are to be presented.
  C. Designing instructional situations for accomplishing the desired learning. This subsection is broken down into more detailed considerations, dealing with obtaining initial comprehension of instructional materials and long-range retention, and minimizing learning interference.

III. *Evaluation.* This section deals with evaluating both student learning and the program of instruction.

The author's primary concern is with constructing and conducting mass instructional programs for adolescents and adults. In this kind of program: (1) The major problem is that of assembling skills from previously learned behavioral components. (2) The control of learning is paramount over the presentation of information. (3) The cost of controlling learning can be justified in terms of expected savings from improved instruction. (4) The construction of the program will probably involve coordinating the activities of several different groups of workers. Although many of the principles, techniques, and strategies appropriate to this kind of instructional situation are also appropriate to others, it is well beyond the scope of this paper to try to spell out all the differences and similarities that may be involved. Consequently, any generalizations from this situation to related situations are made purely at the reader's discretion.

I. WHAT IS INSTRUCTION?

How Is Instruction Related to Learning?

Instruction is effective only to the extent that the desired learning occurs. If none of the desired learning occurs, then we are forced to conclude that no instruction has occurred. The late Edwin R. Guthrie[1] defined learning as "changes in behavior which follow behavior." Thus, learning consists of responding "differently to a situation because of past responses to the situation." Consequently, during learning the student will be engaged in the production of behavioral responses. Instruction, on the other hand, is concerned with the arrangement of situations designed to elicit from the student those behaviors that it is desired that he learn. The production of behavioral responses by the student is the integral constituent of both learning and instruction. Or as Guthrie[2] noted, "A student does not learn what was in a lecture or book. He learns what the lecture or book causes him to do."

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[1] E.R. Guthrie, " The Psychology of Learning," (Revised Edition) Harper and Brothers, New York, N.Y., 1952.

[2] ——, "Conditioning: A Theory of Learning in Terms of Stimulus, Response, and Association." *The Psychology of Learning,* Natl. Soc. Stud. Educ., 41st Yearbook, part 2, 1942, pp. 17-60.

Guthrie's definition of learning does not imply purpose or improvement, but simply "changes in behavior which follow behavior." Purpose is imposed upon learning as a consequence of the behaviors that are selected for the student to learn. Improvement is imposed upon learning as a consequence of the arrangement of situations designed to evoke the behaviors selected for the student to learn. Thus, both purpose and improvement are parts of the process of instruction which are not inherent in learning. Instruction is specifically concerned with providing purpose to learning, and improvement in learning, with respect to the designated purpose.

Behavioral Descriptions and the Specifications of Instructional Programs

The problem of specifying an instructional program that will lead as directly as possible to effective control of student learning is largely a problem of adequately describing the behaviors required of students at specified points in the instructional program. Behavior, however, is a difficult thing to describe, not only because it is continuously changing, but also because there are so many different characteristics of it that we could select to describe at different levels. For instance, we might describe muscular and anatomical *movements* and glandular responses in such minute detail that a description could be generated only after the fact, and could fit only the single behavioral events for which it was generated; that is, the behavior would be nonrepetitive in that we could never expect to observe another behavioral event that would fit every detail of the description. Or we might instead describe behavioral *acts* in terms of gross segments along various descriptive dimensions applicable to muscular and anatomical movements and glandular responses. Since such descriptions could fit many behavioral events, we could use them to denote repetitive behaviors, and we would thus be provided with at least the possibility of predicting behavior in future situations. This, of course, is the basic goal of behavioral science. Note, however, that there is no *single* level at which behavioral acts might be described. A greater number of behavioral events will fit gross descriptions than will fit detailed descriptions; consequently, gross descriptions will be more repetitive and easier to predict. And they will generally possess less practical utility.

Instead of describing behavior in terms of characteristics of muscular and anatomical movements or acts, we might find it more useful in some instances to describe it in terms of its effects, accomplishments, or goals. This kind of description we designate as behavioral skill rather than as behavioral movements and acts. The goal constitutes the intrinsic characteristic of descriptions of skill. Skills may also be described at many different levels of generality. And, again, the grosser the level of description, the more repetitive and easier to predict will be the skill and the less its practical utility.

There is another aspect to describing behavior that we must also consider. This is the problem of who does the describing. Suppose that we were observing Joe B., an engineer, sitting in his swivel chair with his feet propped up on his desk. We might observe that Joe scratches his right ear with his right hand, runs his right index finger around the right side of his neck under his collar, convulsively jerks his left foot three times, and shifts his weight on his buttocks, in sequence. Our report of Joe's behavior would probably not significantly impress his supervisor. If, however, we were to ask Joe to describe what he had been doing during this same period of time, he might reply, "Well, I was mulling over this circuit design problem we have been having on equipment X and I think I've got it licked." He might then proceed to put some diagrams, symbols, and calculations on the blackboard to substantiate his reply. This description of Joe's behavior would probably make a significant impression upon his supervisor. That which is described may be quite different, depending on whether it is described by an external observer or by the behaving organism itself. There are some aspects of behavior which are not generally open to external observation. It is, of course, debatable whether these unobservables (*i.e.*, thinking) constitute behavior. I contend that they do. Furthermore, there are instances in which some of these unobservables become observable. Though most of us go through long years of being trained not to externalize our thinking, I must confess that I do occasionally get caught at it. For instance, frequently when I am alone I do my "thinking" out loud, or at least engage in some small but perceptible throat, tongue, and lip movements.

It should be obvious by now that it is not enough simply to exhort educators and training specialists to describe jobs and instructional programs in terms of behavior, for still unanswered are such questions as whether to describe behavior in terms of movements and acts or in terms of skills, in terms of the behaving organism or in terms of an external observer, and at a gross or a detailed level. All these modes of description are appropriate, but for different purposes. In general, the behaviors that are selected for description (*i.e.*, those that students in a program of instruction will be required to learn) are selected with respect to the behaving organism. For instance, in building an instructional program for the training of engineers, we would select those behaviors which are of significance to practicing engineers whether or not they are available to external observation. The student, however, may be required on occasion to externalize his "thinking" so that the instructor can either evaluate his progress or decide what instructional presentation to make next. Thus, for purposes of controlling instruction, behavior should be described with respect to an external observer. Whether the student "thinks" to himself or talks out loud may have little effect upon his actual learning, although talking out loud will generally be more time consuming than "thinking." The instructor, however, cannot evaluate the student's progress or alter his instructional presentations unless the student engages in relevant externally observable behavior.

Descriptions of behavior in terms of skill are necessary so that the instruction can impose purpose or direction upon student learning and provide for improvement towards that purpose. Without the specification of skill requirements, we would have no way of determining the adequacy of the movements and acts actually practiced and learned by the student. The student, however, does not directly learn the effects of movements and acts; instead, he learns the movements and acts that produce the effects. Consequently, descriptions of the movements and acts are generally needed as a basis for designing the instructional material actually used by the student.

The most detailed level at which each of these behavioral characteristics should be described depends largely upon the ability of the users of the descriptions to comprehend them correctly. For instance, the ultimate users of movement-and-act characteristics of behaviors are the students themselves, and the level of detail at which these characteristics should be specified depends primarily upon the level of comprehension of the incoming students, that is, previous education, training and experience, abilities and aptitudes, and so forth. In fact, it may not always be necessary to specify the movement-and-act characteristics of all the behaviors required for a given job. Students may enter the instructional program with the movements and acts necessary for producing some skill effects already in their repertory. This, for instance, is true of the verbal behaviors required in the great majority of instructional programs for adolescents and adults. Thus, the major instructional problem may be, and generally is, one of assembling already possessed skills into more complex skills.

The preparation of behavioral descriptions for instruction purposes will frequently involve several groups of workers, that is, task analysts to prepare skill descriptions of the job with regard to an external observer; training analysts to derive and prepare movement-and-act and skill descriptions of the job with regard to the behaving organism, on the basis of the task analysts' descriptions; and instructors and technical writers to prepare instructional material on the basis of training analysts' descriptions. In each instance, that which is described and the level at which it is described will depend upon the needs of the next group in the sequence to perform its part of the design of instruction.

Thus we see that in deriving and specifying the behaviors requisite for a given instruction program, there are several characteristics of behavior with which we should be concerned as a basis for determining what needs to be learned and for effecting adequate control of such learning as follows:

(1) Movement and act descriptions.
(2) Skill descriptions.
(3) Descriptions with respect to an external observer.
(4) Descriptions with respect to the behaving organism.
(5) Different levels of descriptive detail.

Distinguishing Between Presentation and Instruction

Most traditional methods of mass instruction, lectures, conventional textbooks, demonstrations, are for the most part simply methods for presenting information to students. Although the presentation of information is an important aspect of instruction, it does not in itself constitute a complete method of instruction. Learning must inevitably involve the production of some kind of behavioral response by the student. Effective instruction not only presents information to students, but also attempts to present information in such a manner as to lead the students into making the desired behavioral responses. Dressel[1] has bluntly stated, "Classroom practices which are restricted to textural or teacher presentation of knowledge and the testing of the extent of recall of this knowledge are unworthy of the name of instruction. . . . The teacher covers content but does not instruct students. The majority of students remain completely passive, and work only to memorize what the teacher emphasizes."

This distinction between instruction and the presentation of information is one which should be belabored, in view of the widespread belief that education's great leap into the future can be made via mass *information* media such as films and television. Such techniques primarily expand the lecture or demonstration beyond the walls of the classroom, but do not in themselves constitute complete instructional methods; that is, they do not attempt to control student behavioral responses in such a way as to maximize learning effectiveness and efficiency.

II. THE MAJOR STEPS IN THE CONSTRUCTION OF MASS INSTRUCTIONAL PROGRAMS

As previously indicated in the Introduction the major steps in the construction of mass instruction programs are:

A. Identifying the material to be learned.
B. Sequencing the order in which instructional materials are to be presented.
C. Designing instructional situations for accomplishing the desired learning.

A. Identifying the Material To Be Learned

A complete instructional program that does in fact effectively control the student's learning may not necessarily be adequate if it does not inculcate behaviors in the students which are pertinent to the job situations in which they will eventually be required to perform. For instance, an electronics maintenance program that teaches its students how to design electronic circuits rather than how to troubleshoot them will turn out inadequate job holders regardless of the effectiveness of its instructional methods. Improving the effectiveness of instruction in such a program would only lead to the more efficient production of equally incompetent graduates.

In constructing instructional programs for producing graduates who are capable of performing a given job, it is patently obvious that in most instances the students will need to learn considerably more than just those behaviors that are available to external observation on the job. Certainly, an electronics technician needs to know something about "theory" and "troubleshooting strategies." Such verbal behaviors are not available to external observation during normal performance of the job. Simply granting that such unobservable verbal behaviors are important to obtaining adequate job performance, or that job behaviors should be described with regard to the behaving organism rather than with regard to an external observer, tells us nothing about how to go about identifying these behaviors so that they can be described. In order to understand better what unobservable verbal behaviors need to be described, we must first challenge the basic notion that such behaviors are necessary for obtaining adequate job performance.

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[1] P.L. Dressel, "Evaluation as Instruction," *Proc. 1953 Invitational Conf. on Testing Problems*, Educational Testing Service, Princeton, N.J., 1954.

Identifying One Role of Unobservable Verbal Behaviors

How do we identify these externally unobservable verbal behaviors? What are their essential characteristics? The answers that we can obtain to these questions at this time are at best primitive. Let us begin a search for answers to these questions by taking a close look at three hypothetical instructional situations.

Situation 1. Nonverbal instruction: The instructor demonstrates a behavioral activity to his students, and the students then attempt to imitate the instructor's demonstration. Such demonstration-imitation trials continue until the students can perform the activity without error. Such a method is obviously slow and greatly restricts the number of students that one instructor can handle. To handle all the instruction for a complex job in this fashion might well consume the entire lives of both the students and the instructor—and even that length of time might not be sufficient.

Situation 2. Unlearned verbal instructions: The instructor is allowed to communicate verbally with his students. He provides his students with verbal instruction for performing each step of the activity. It would seem reasonable for him to begin with a demonstration of the activity, after which he would verbally lead his students through the activity step by step, providing them with detailed verbal instructions for each step immediately before its performance. His objective, however, is to enable his students to perform the activity without his continued verbal guidance. Thus, he would gradually withdraw the verbal guidance from successive practice trials until the students could perform the activity correctly without any verbal guidance whatsoever. In terms of instructional feasibility and economy, this situation constitutes an obvious improvement over the first.

Situation 3. Learned verbal instructions: The instructor requires his students to learn the verbal instructions for performing the activity or part of the activity, and then to practice it by generating their own verbal instruction. This would appear to be the most advantageous instructional situation for imparting the great majority of skills that adolescents and adults may be required to learn. The movements and acts by which such skills are produced only infrequently constitute new behaviors for the adult human. In addition, there are generally some verbal instructions available which can be used to elicit the movements and acts; that is, the movements and acts are generally under verbal control. Thus, the student may already possess the ability to produce the movements and acts as a consequence of verbal stimulation; that is, if he is told what to do in sufficient detail, he can do it. Consequently, the major instructional problem will be that of having the student learn how to generate his own verbal stimulation or verbal instructions for correctly performing the skill.

Some Factors Affecting the Learning of Verbal Instructions

Once we have made the decision to employ learned verbal instructions in the production of skilled performance, there are certain factors which we should take into account in designing the verbal instructions themselves. Let us consider a hypothetical example. Suppose we have an activity or skill consisting of a sequence of 25 steps. To train a student to perform (that is, both learn and remember) these 25 steps in sequence without introducing any verbal instruction other than that involved in telling him how to perform each step singly would be time consuming and costly. Such a procedure would tend to restrict the cues for initiating a step to the termination of the preceding step and, at least during early learning, would not restrict errors between remote steps of the chain. For instance, the student might easily confuse step 2 with step 18. How might the verbal controls be better designed to facilitate learning and retention?

Let us seek an answer to this question by first drawing an analogy between human beings and computers—an analogy quite similar to one made several years ago by Miller.[1] The construction of a system of verbal controls for facilitating learning and retention is in many ways akin to the construction of a retrieval program for a computer. Although the human computer has tremendous capacity in its permanent storage facility, it does not possess random access. Access to this permanent storage generally has to be made through a working memory of very limited capacity. This limited capacity would appear to be determined by the span of immediate memory. The average span of immediate memory over a wide variety of materials and people is around 7 items.[2] Thus, we want to design verbal control in such a way that there will never be a need for more than 7 items in the working memory in any one instance. Since 7 is an average figure over people and materials, we would in practice generally want to restrict the maximum number of items ever actually needed in the working memory at any one instant to some number less than 7, so as not to operate the working memory continuously at maximum capacity, or beyond the maximum of many students.

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[1] G.A. Miller, "Human Memory and the Storage of Information," *IRE Trans. on Information Theory*, vol. IT-2, September 1956, pp. 129-137.

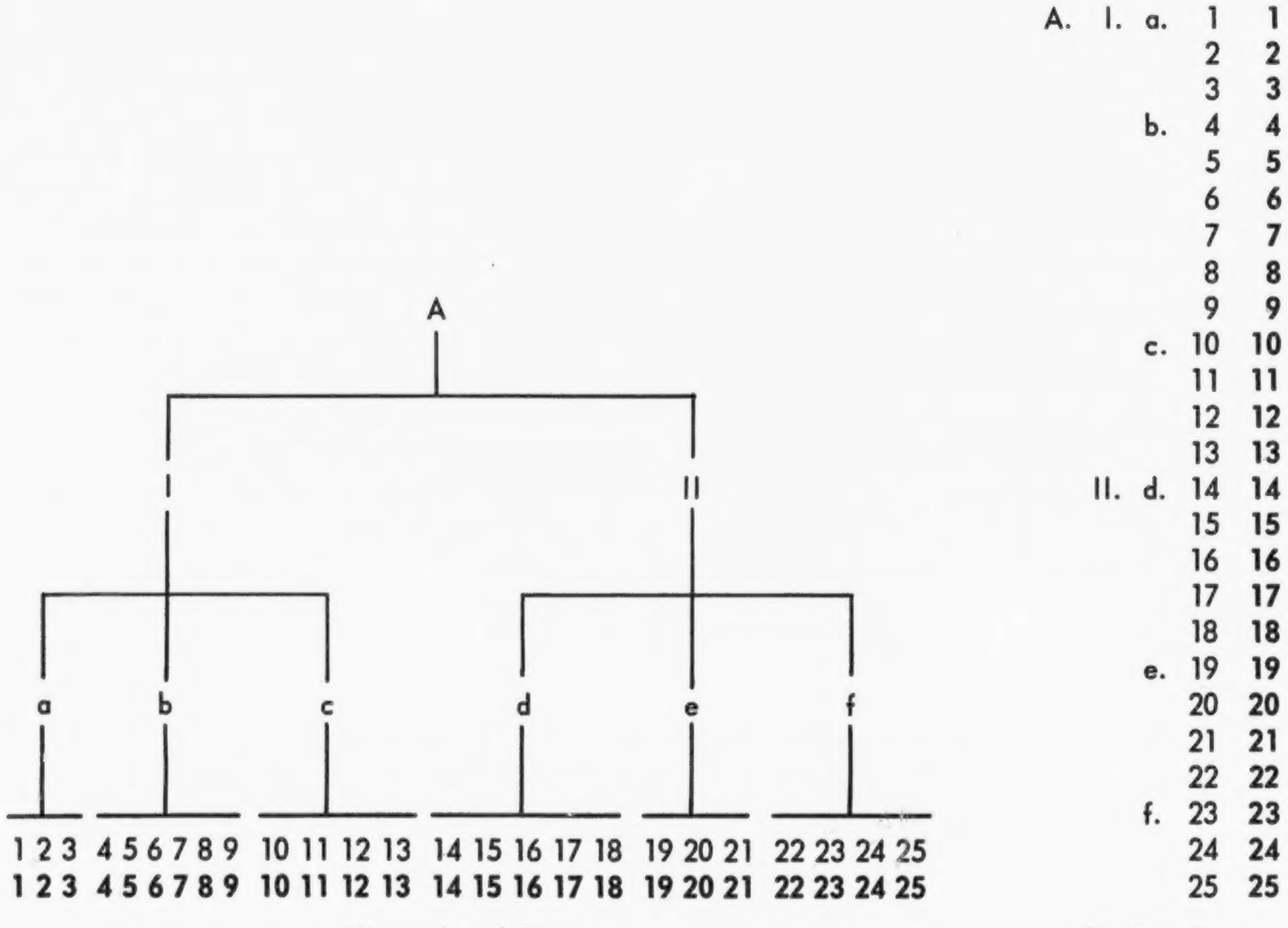
[2] G.A. Miller, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information," *Psychol. Rev.*, vol. 63, 1956, pp. 81-97.

The Organization of Verbal Instructions

We can and frequently do reduce the load on the working memory by organizing verbal material into a hierarchical arrangement or outline. For example, the tables of contents of many books (particularly many published before the twentieth century) are organized into an outline format with heads and subheads, topics and subtopics, and so forth.

In order to see what role this restriction on the span of immediate memory plays in our development of verbal controls for skilled performance, let us again consider the hypothetical activity consisting of 25 discrete steps, as diagramed in Figure 1. The bold-faced numbers from 1 to 25 at the base of the triangle represent the externally observable motor (*i.e.*, nonverbal) acts required to accomplish each step in the activity. The matching light-faced numbers immediately above the bottom row represent the specific verbal instructions necessary for eliciting the motor acts required to accomplish each step in the activity.

I have already indicated that an instruction method which would simply require students to learn the motor acts in the individual steps as a sequence with no verbal controls would not be a particularly efficient method of utilizing both time and money. The introduction of



Hierarchical Form

Outline Form

Figure 1

verbal instructions for each step does constitute an improvement, but it still would not be particularly efficient simply to require that the student learn the verbal instructions as a simple chain of verbal behaviors. However, we can break this sequence of 25 steps in subgroups in which each group would consist of 7 or fewer steps. Thus, in selecting the steps which he is to perform next the student need not consider more than 7 items at any one time. Such grouping, of course, should not be completely arbitrary. Steps that seem to have some common function or goal should be grouped together. Thus, in a real situation, we would probably not have the same number of steps in each group. The common function of each group of steps becomes a label for that group and this label in turn constitutes a step in a sequence described at a grosser level.

Now suppose that the entire sequence has a general function or overall goal, *A*. Then the names or labels given to our groups are in fact subfunctions or suboperations which must be accomplished in order to obtain the general function *A*. Our system of verbal controls thus assumes a hierarchical arrangement. This is the same type of arrangement that has been proposed by Miller, Galanter, and Pribram[1] for the human storage of what they term *plans*.

If we now turn the hierarchical structure in Figure 1 on its side and rearrange the terms slightly, without changing the relations among them, we see that what we have been doing is actually quite similar to old familiar procedures for outlining. The main thing we have done so far is to place a restriction upon the number of elements in the categories of our outline. It becomes obvious that there is also a second restriction to be placed upon outlining procedures. The entries themselves must be designed so as to be "rememberable." This implies that they should be short and should bear some clear relationship to the succeeding terms in the outline or to the motor acts which they are to elicit.

Some readers may be of the opinion that such outlines are trivial and are certainly not a significant aspect of the learning requirements laid on the student. Let me answer this charge by asking these same readers to reflect back on their own experiences. When faced with a particularly difficult or complex section of textual material, how many of you have deliberately developed an outline of the material specifically to facilitate your learning and remembering of it? Certainly the outline does not constitute all that a student may be required to learn, but it does provide him with a basic framework of associations within which he can organize and integrate other associations.

The organization of verbal material that I am suggesting is not new. Textbook writers, instructors, and students have been doing this kind of thing for centuries. I have simply attempted to present some of the reasons for organizing materials in this manner, together with the implications of these reasons for improving the organization of verbal material in instructional programs. However, there are still many unresolved problems concerning the construction of such verbal outlines or hierarchies. The hypothetical example that I have given is restricted to a single activity, and for such single activities, the construction of verbal hierarchies appears to be pretty straightforward. Still unanswered are questions concerning the degree to which we can build similar hierarchies for controlling the performance of several similar activities, and thus reduce the amount of verbal material that the student will have to learn; and concerning the construction of such hierarchies for controlling the performance of activities that consist of complex branching chains containing many choice points, rather than simple linear chains as in the example.

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[1] G.A. Miller, E. Galanter, and K.H. Pribram, "Plans and the Structure of Behavior," Henry Holt and Company, New York, 1960.

The Advantages of Employing Verbal Controls of Job Performance

There are many advantages which accrue to the use of well-designed verbal behaviors as a means of controlling skill performance. If the discrete motor acts required for skill performance already exist singly in the behavioral repertory of incoming students, so that the major learning problem is that of assembling these motor acts into some proper sequence for producing the skill, then assembly and sequencing can probably be done most efficiently and effectively by means of verbal controls (*i.e.*, learned verbal instructions for performing the skill). Verbal behaviors can generally be practiced more rapidly than can motor behaviors. Thus: (1) The verbal behaviors would allow us to have more practice per unit time than could otherwise be obtained. (2) We could reduce the amount of time which individual students would have to spend practicing on expensive training devices whose use requires the production of motor acts. The sequencing of motor acts could be learned verbally away from such devices. (3) The initial comprehension and long-range retention of verbal material can be greatly facilitated by adroit use of associative supports, such as analogies and mnemonic (memory) devices. (4) It is possible to build generality into verbal systems so as to provide for greatly increased transfer of training from one job situation to another.

B. Sequencing the Order in Which Behaviors Are To Be Learned

The order in which behaviors are learned greatly affects the efficiency and effectiveness with which such learning is accomplished. Few, if any, of us would disagree with this statement. But it says nothing about what order is most efficient and effective, nor does it indicate what characteristics of behavior should be considered in determining an efficient and effective order.

A general solution to these problems begins to form when we carefully examine the behaviors that we want our students to learn. We are not interested in having the specified movements and acts occur on the job in a random manner. Rather, we want each to occur only in circumscribed stimulus situations; that is, we want to establish specific associations between stimulus conditions and movement-and-act responses. An association consists of a stimulus situation or cue and a behavioral response occasioned by that cue. The response may in turn produce sensations which can be used as a cue for occasioning another response. Thus, we can have associative chains of responses in which the first response produces the cue for the second, the second produces the cue for the third, and so forth. One important fact about associations and associative chains that we should keep in mind is that they possess direction; that is, a given cue must precede a given response, which in turn produces the cue for a subsequent response, and so forth.

In the verbal hierarchies or outlines mentioned above (Section II-A), there is not a simple chain of responses but rather a net of responses. In order to transform this net of responses into a net of associations, we need to determine the source of the cue for eliciting each response in the net.

In actually using a learned verbal hierarchy on the job, the student will enter it at the top and work down to the bottom, rather than entering at the bottom and working to the top. In addition to using the associations from top to bottom, he will also need to use the temporal associations from left to right. Thus, the cue for any given response will always appear in the hierarchy to the left of or above the response. Consequently, for any given hierarchy, student practice will proceed from whole to part, or from general to specific, and will maintain the temporal associations in order at each level of the hierarchy.

The learning requirements for a job will frequently consist of at least several associative hierarchies that are relatively independent of each other; that is, they might be viewed as subjobs within the overall job. Generally, we will want to sequence these subjobs so as to minimize the amount of new learning required of the student in going from one to the next. Thus, the first subjob that the incoming student would be required to learn would be the one that he could learn the most easily and quickly, the second subjob would be the one that the student could learn most easily and quickly having already learned the first, and so on.

C. Designing Instructional Situations for Accomplishing and Insuring the Learning of Specified Behaviors

As indicated in the Introduction, this subsection will deal with three problem areas, as follows:

Obtaining initial comprehension.
Obtaining long-range retention.
Minimizing interference with learning.

Obtaining Initial Comprehension

Since the entire program cannot be learned at once, the first problem is to select the size of the learning or practice unit. On the one hand, we want to avoid units that are so large that the student is unable to retain the material presented in the early part of the unit until the entire unit has been presented. On the other hand, we want to avoid units that are so small that once the student has learned them he still faces a major learning requirement in having to learn to put them together. This is the old problem of whole-versus-part practice and, unfortunately, there is no simple solution for it. There are many factors that enter into a decision concerning the size of the practice unit; of these, the following are probably most important:

(1) The nature of the material.
(2) The general intelligence of the student.
(3) The student's previous education and experience.
(4) The particular stage of practice at which the student has arrived.

In very general terms, larger units would appear to be more effective with brighter, better-educated students, with material having a definite sequence or organization, and in the later stages of practice. Several different methods for solving this problem have been suggested, of which the most generally applicable is a "whole" method which allows for extra repetition of difficult parts within the context of the whole. The basic problem, of course, is not whole versus part, but rather "How big a part?" Other factors also seem to play a role in determining the size of the practice unit, but they are factors that are extremely difficult to identify or define. For instance, a factor grossly connoted *associative cohesiveness* may have a bearing on this problem.

It will frequently not be possible, using a single instructional presentation, to lead all of the students into producing all the behaviors involved in a single practice unit. A series of instructional presentations preceding the first presentation of the complete practice unit may be necessary if all of the component behaviors do not already exist in the students' behavioral repertory. Instruction is usually concerned with assembling the behavioral acts out of component movements or out of acts already in the students' repertory. This in itself may be a many-step process involving the assembly of small acts into larger acts, which in turn are assembled into still larger acts, which in turn are assembled into the complex skills called for by the job. The problem is further complicated by the fact that all students do not possess precisely the same initial repertory. Thus, some students may have to be started at a very detailed level and others at a more gross level. To complicate the picture yet further, some behaviors defined as skills rather than as movements and acts may be adequately accomplished by any of a wide variety of movement-and-act combinations. Because of wide individual differences in the students' initial behavioral repertories, some of these combinations might be more readily learned by some students, and others by other students. Thus, it may be necessary to lead different students up to each complete practice unit by different routes.

Obtaining Long-Range Retention

Our concern is not simply to obtain adequate performance from students during and at the end of instruction, but also to obtain adequate performance in an ultimate job situation after formal instruction has ended. Consequently, factors which effect long-range retention are crucial to the design of any truly effective instruction program. The previously mentioned hierarchical organization of contrived verbal behaviors constitutes one such factor. There are two other major factors with which we should be concerned.

First, during the early stages of learning we may frequently find it necessary to introduce various degrees and forms of guidance (hints, prompts, and analogies, for instance) as a means of obtaining the production of those behaviors that we want the student to learn. Such guidance will not be present in the job situation, and consequently it is necessary that the student learn to produce the behavior without the guidance. Therefore, such guidance must be removed or faded from succeeding practice trials, and it may need to be faded at different rates for different students. Simply fading guidance from the instructional presentation may in itself not be sufficient. Such guidance may continue to exist as unobservable behavior in the student for short periods of time. Thus, it is necessary not only to fade guidance from the instructional presentations, but also to fade it from the student's immediate memory.

Guidance provides a means for controlling student response immediately preceding and during the actual production of each response. Immediate knowledge of results, or feedback, provides a method for controlling student response immediately after the production of each response. Feedback to the student concerning the adequacy of each response or sets of responses immediately after its production serves two purposes:

(1) If the response was incorrect, feedback serves as a cue for trying a different response to the same situation and may provide additional guidance to facilitate occurrence of the correct response.

(2) If the response was correct, feedback serves as a cue to terminate further response in that situation and sets the stage for the occurrence of a new situation.

If the student does not produce the correct response or set of responses for a given situation, he should not be allowed to proceed to another situation requiring a different response. He must produce the correct response for each situation before proceeding in the instructional program, even though obtaining the production of a correct response in the first situation may require the introduction of very heavy guidance. Such guidance, in turn, should be faded from ensuing similar instructional situations. Feedback should be provided for each practice unit rather than for each behavioral component within a practice unit. Note, however, that the practice unit may vary in size, depending on the nature of the material, the intelligence and previous education of the student, and the particular stage in practice at which the student has arrived.

Second, irrespective of different opinions concerning the basic nature of learning, I am sure that we will all agree that practice is one crucial factor affecting learning. One major problem in designing an instructional program, however, is that of integrating the various practice schedules for each of the different kinds of behaviors that we want the students to learn. For instance, in employing distributed practice in an instructional program, we are faced with the problem of providing activities for the student to perform during the periods between practice trials. The selection and design of these interpolated activities may be more critical to the learning of a given behavior than is the determination of a maximally efficient temporal practice schedule for that behavior. Although some general principles for solving this kind of problem do exist in the psychological literature, they have not been sufficiently well spelled-out to preclude the need for a large portion of "art."

Minimizing Interference With Learning

There are three major sources of interference with learning in instruction programs.

(1) Inadequate instructional activities.
(2) Improper administrative and management practices.
(3) Students' interpersonal problems.

In every instance the interference occurs as behaviors that are incompatible with the occurrence of behaviors that the student needs to learn. In the first instance, such incompatible behaviors consist of incorrect behavioral responses to various instructional presentations. For reasons of efficiency and effectiveness, we want to guard against the occurrence of incorrect behavioral responses throughout the entire course of learning. Some have objected to stringent application of this principle, claiming that there are times when it is desirable for students to learn to distinguish between correct and incorrect responses to a situation. This contention is quite valid, but irrelevant. It should be noted that there is a difference between learning an incorrect behavioral response and learning that a behavioral response is incorrect. The occurrence of incorrect responses can be reduced to the point of being virtually negligible through the adroit use of various forms of guidance in the early stages of learning and by employing practice units of a proper size in each stage of learning. Practice units should generally be small in the early stages of learning and become progressively larger in the later stages.

Incorrect responses in other than negligible amounts can detract from the effectiveness and efficiency of an instructional program because of their incompatibility with the correct responses. Incorrect responses, however, are not the only behaviors which may occur during an instructional program that are incompatible with the occurrence of the behaviors that the student needs to learn. Other incompatible behaviors in the form of tension anxiety, or worry can be introduced into the instructional situation by improper administrative and management practices. For instance, such a situation can arise if the instructor terrorizes his students with a dread of coming examinations, or if a student enters an instructional program as a means of preparing for a career field and then finds that his chances for placement in his chosen career field are small. Factors beyond the direct control of the school may also lead to the occurrence of incompatible behaviors during instruction. For instance, the student may have financial troubles, or he may have any variety of interpersonal problems which produce behaviors that interfere with those required for successful completion of the instruction program. Many of the factors leading to the production of incompatible behaviors may be eradicated or at least alleviated through proper counseling and guidance services. Such services should be an integral part of the management structure of all large instructional institutions, for they can and should contribute to the effectiveness and efficiency of instruction.

III. EVALUATION

There are two major aspects to instructional evaluation. The first is evaluating the effectiveness of the instruction itself in inculcating students with the behaviors selected for them to learn. The second is evaluating the effectiveness of the behaviors selected for the student to learn for producing adequate job performance. Thus, the first is concerned with the effectiveness of the instructional situations and their arrangement for producing improvement in learning with respect to the purpose of instruction, while the second is concerned with the adequacy of the instructional purpose itself for producing adequate job performance.

Basically, a test is a procedure for gathering data about specified behaviors in order to make a decision about those behaviors. The first step in constructing an achievement test for evaluating the effectiveness of the instruction is that of determining the kinds of decisions or actions that are to be based upon the outcome of the test. Thus, the tests or data-gathering procedures should be tailored to the decisions that will be made on the basis of such data. If we are constructing a major end-of-phase or end-of-course examination, we will be primarily concerned with determining those students who have learned the specified behaviors and those who have not, that is, students who are to pass and students who are to fail. The fact that some passing students learn more than other passing students is of little concern to us unless we are going to base some action on this difference. There is little point in differentiating between students unless they are to be differently treated.

Ideally successful instruction should produce students all of whom make a perfect score on the achievement tests; that is, the resulting distribution should have a variance of zero and a mean equal to the maximum possible score. This, of course, is an ideal which is virtually impossible to realize. However, the mean and variance of the distribution of the achievement test scores should be a function of the adequacy of the selection procedures and instructional activities, but not a requisite characteristic of the test. Instructors having become overly concerned with such things as item difficulties, interitem correlations, and the shape of the distribution of scores. Not one of these is a relevant test characteristic for ideally successful instruction. By far the most important characteristic of a test is the validity of the behaviors required for its successful completion to adequate performance in the ultimate job situation. From the point of view of the behaving organism (*i.e.*, the student who goes on to perform the job), we want to maximize the degree of congruence between the behaviors he practices during instruction, the behaviors required of him for successful completion of the examinations, and the behaviors required of him for successful job performance.

A large proportion of the behaviors practiced by students during instruction and required of them for successful job performance are not normally available to external observation, but need to be made observable for evaluation purposes. In making unobservable behaviors observable for evaluation purposes, it is extremely important that we not change significantly the behavior or the conditions in which it occurs. We must be careful to make only those minimum changes required for making the behavior observable. Unobservable behaviors may sometimes be inferred to have occurred on the basis of the occurrence of an observable behavior. For instance, in many instructional situations our concern is primarily with the student's unobservable verbal behavior (*i.e.*, "thinking") which we might assess by means of a multiple-choice test. We assume that the student's placing an X beside the correct choice in an item was immediately preceded by the occurrence of a desired verbal behavior; that is, he "thought" the problem through properly. Our concern is not with the student's X-making behavior, but rather with the unobservable verbal behaviors which we infer to have occurred by the placement of the X. The adequacy of this type of measurement depends primarily upon our being able to justify this inference.

The construction of achievement tests should not be left to the arbitrary whims of individual instructors. The criterion for student learning should be clearly stated in a statement of instructional objectives. Besides clearly specifying the behaviors to be possessed by the students at the termination of instruction, it should tell the instructor how to go about deciding at that time which students will pass and which will fail. Cureton[1] has made this point quite well in stating that: "The *de facto* aims of an educational program, and of every part thereof, consist of those acts on the basis of which the students and the program are in fact evaluated. If any stated aim is not analyzed into specific actions and those actions observed and scored and reported, the statement is no more than empty verbiage." The statement of instructional objectives should contain a specification of the behaviors that will be evaluated at the end of instruction, and all the behaviors that are in fact evaluated at the end of instruction should be clearly specified in the statement of instructional objectives.

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[1] E.E. Cureton, "Validity," in *Educational Measurement*, E.F. Lindquist, (ed.) American Council on Education, Washington, 1951.

A statement of instructional objectives can be viewed as constituting a prescription for constructing an achievement test, or it may, in some instances, actually be an achievement test. Ebel,[1] for instance, has suggested that one way by which instructional objectives might be clearly specified is by building an extended series of test items to be used as a basis for evaluating achievement in a program of instruction *before* the program of instruction itself is built.

The second major aspect of evaluation, that is, evaluating the effectiveness of behaviors selected for the student to learn for producing adequate job performance, is accomplished, basically, by determining the adequacy of job performance of students who have successfully completed the instructional program. For jobs that already exist, such evaluation may be accomplished by means of job-sample proficiency tests, observations of on-the-job performance, supervisory evaluations, and so forth. For jobs that do not already exist and which may not exist for some time to come, the problem is exceedingly more difficult and, for the most part, has not been resolved.

CONCLUSION AND IMPLICATIONS

My primary effort has been to present a conceptual view of instruction as a system for controlling student behavior so as to modify it to conform to a predetermined pattern. Major emphasis has been given to the problem of determining the nature of the terminal behavior pattern with respect to the behaving organism itself. Secondary emphasis has been given to the problems of determining the size and composition of the practice unit, the integration of practice schedules, and the minimization of interference with learning. Evaluation has been treated as a decision-making process concerned with the adequacy of the instructional activities for modifying student behavior and the adequacy of the terminal behavior pattern for producing the necessary job-performance capabilities.

This paper presents nothing more than a broad conceptual framework to serve as a tool for identifying research and implementation problems, and a general approach to the solution of these problems. The major goal toward which research efforts need to be oriented is that of developing rationales and procedures for constructing and conducting mass instructional programs. Such goals cannot be realized by developmental projects whose primary purpose is the construction of an instructional program as a consumer product. The development of consumer products and the development of technological procedures cannot be equally emphasized in the same project. One will invariably have to be sacrificed to the other, usually to the detriment of technological development.

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[1] R.L. Ebel, "Obtaining and Reporting Evidence on Content Validity," *Educ. Psychol. Measurement*, vol. 16, no. 3, 1956, pp. 269-282.

SOME RESEARCH NEEDS IN SELECTING AND TRAINING PROGRAMERS[1]

William H. Melching

The full potentialities of automated instruction can be achieved only if competent programers can be selected and trained. Personality components such as relatively high intelligence, interests, attitudes, and flexibility are discussed.

A wave of enthusiasm has accompanied the birth and growth of a special activity called "automated instruction" or "programed learning." The enthusiasm has been so great that there is hardly an agency or institution engaged in education or training that has not been intrigued by the potentialities of automated instruction. Modern-day visionaries foresee marvelous developments in this area.

Upon the preparation of appropriate programs and the development of reliable automatic teaching devices, increased masses of students can master unlimited amounts of study material. All individuals, irrespective of differences in intellectual capacity and experience, can, as if by magic, be brought to some common level of performance. I do not intend to imply, of course, that the automatic teaching device is perceived as a panacea by all individuals interested in the area of programed instruction. Many are approaching the area with reserve and caution. Nonetheless, some enthusiasts would seem to be proclaiming that although men may not be *created* equal, they may be *made* equal.

The need for a revolution in education and training has been succinctly expressed by Ramo (1). "We are in rapid transition today to a new world which threatens to be dominated by technological advance. . . . This rapid and potentially dislocating scientific advance can be expected to heighten . . . the coming crisis in education . . . Our technical growth is paralleled by social maladjustments still left over from previous eras . . . Education should be at the head of the list for priority attention . . . What is needed is a technique of education which is in keeping with the world ahead."

Ramo then proceeds to describe a "modern" school of the future—the only kind of educational system that can hope to narrow the gap between human social knowledge and technical knowledge. Ramo conceives of a highly automated program of instruction where machines are in very sensitive and responsive communication with the student. Classrooms are elaborately equipped with push-button apparatus sufficient for the efficient teaching of all kinds of knowledge and skills. The interactive capacity of this special teaching machine is significant, for the machine behaves like an inexhaustible private tutor.

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[1] Paper for Symposium, "Some Research Needs in Programmed Learning and in Training Programmers," at Texas Psychological Association, Dallas, Texas, December, 1961.

It is obvious from this brief description that Ramo is suggesting that advanced technical knowledge should be used in constructing the devices to provide the educational skills that are necessary, in turn, to utilize the technical knowledge.

To accomplish this feat, Ramo conceives the possibility of a new profession called "teaching engineer" which would be concerned with this educational process. One aspect would relate to the design of the machines, and another would focus on the design of the material for the machines.

Because of the tremendous advances in technical knowledge it may be assumed that the design and the development of the kinds of machines envisioned by Ramo are well within reasonable expectations, and that their production could proceed with few major problems.

The second task of the teaching engineer—the design of material for the machines—is not as easily resolved, for the procedures to be followed are not explicit. The mechanics of constructing the machine are more readily teachable, apparently, than are the mechanics of preparing the program for use on the machine. Since it seems a truism to say that the machine is only as good as the program to be used on it, and since programs must be prepared by programers, it follows that the full potentialities of automated instruction can be achieved only if programers can be trained to accomplish their tasks adequately.

An important question is now posed: What constitutes a good programer? or to put it another way, how does one become a good programer? The literature is not much help in these problems. There is frequent reference to programing as an art and to recommended techniques to be used by programers. But there is a paucity of information directed at describing the good programer, or what sorts of training might be most profitable in producing good programers. Their selection and training is apparently just as much an art as is programing itself.

Nonetheless, there is a general recognition that programing may require unique skills. For example, Komoski (2) says: "Those who believe the schools should not do programming say that such programming will inevitably result in a great many poor programs, because they will be created by people who do not have the time, talent, training, or temperament requisite to the programming art."

Let us consider some characteristics of programers that may be of importance, and some areas where research into programer characteristics might prove fruitful.

In a relatively early report Donald Smith (3) said: "One of the most striking similarities among the successful programmers with whom I have worked is an inverted style of thinking. The inverted thinker focuses so intensively upon a stimulus configuration, either perceptual or conceptual, that the differentiation process appears to continue far beyond that of the normal. Such a person tends to be analytical, deductive, methodical, perfectionistic—in short, the classical or Jungian introvert."

In another instance, Lysaught (4) presented some comments centering around selection and training of programers. He reported that he found no easy way to anticipate or predict who will be a good programer. In selecting programmers for *computer* operators, it was found that the greatest correlation existed between intelligence and program skill. Yet the most intelligent individuals also became bored with programing. In selecting individuals to program instructional materials, Lysaught narrowed the concentration to those persons whose prime qualification was a deep and abiding interest in the work. These individuals believed in programing and were buoyed up by seeing results of their work. Lysaught noted that programing proceeded more rapidly in some areas than in others, and although no precise results were given, he stated that the difference lay in programers rather than in subject matter.

If these two reports have any validity, we are left with a picture of the successful programer as an intelligent introvert—but not too intelligent. In our attempts to program at the Air Defense Human Research Unit at Fort Bliss, Texas, we have arrived at conclusions similar to those previously expressed. For example, one prospective programer portrayed by his attitude that he did not believe in the programing of material to be learned. The result, of course, was simple; he produced little useful programing.

Other attitudes of programers may be equally detrimental to effective programing. If the programer possesses the attitude that programing is extremely difficult, and that it requires extended periods of reflection intermixed with minutely detailed analyses of each possible step, his production is painfully slow. He is saying, in effect, "Programing is an extremely long and laborious task." And by his work output he proves that he is right.

The description of the successful programer may turn out to be something like this: He is a relatively intelligent individual who accepts the basic premise that the programing of material to be learned is an effective means by which to teach individuals. He openly expresses interest in programing, he believes that he can contribute materially in this activity, and he sets goals for himself that are both realistic and realizable. He is, on the one hand, flexible enough to modify his program or his ideas when necessary while, on the other hand, he is sufficiently compulsive to be able to bring his program to fruition. His primary motivation for these activities is internal.

Although this description is not as precise as or as definitive as one might like, it may provide some useful guidance for research. A cursory examination of the description suggests several personality components of interest:

(1) Relatively high intelligence
(2) Interests in the area
(3) Attitudes favorable to the area and favorable to achieving the goal

(4) Flexibility
(5) Compulsivity
(6) Functional level of motivation

This list of characteristics of the hypothetical programer is certainly not exhaustive; there is no mention, for example, of knowledge of subject matter area, education and experience, effective writing skills, and so forth. A more comprehensive description would include these factors, plus several others.

I would suggest, however, that certain of the factors listed will assume greater significance than others. Thus the ability to express oneself clearly and concisely, the ability to organize and to specify educational objectives in accordance with a prescribed theoretical framework, and so forth, may be skills that are lost if the programer, by his attitude toward his task, demonstrates an unwillingness to move from the theoretical level to an empirical level. Effective writing skill carries little weight if the programer seems unable to arrive at the precise objectives he seeks—and therefore never gets around to writing frames!

The situation mentioned above is perhaps exaggerated, but this was done intentionally because it highlights the dangers involved in becoming somewhat obsessed with those activities customarily thought of as preliminary to frame-writing. The goal of programing is to produce programs, not to demonstrate why frames cannot be written.

I am now in danger of having belabored the point. I am saying that attitudes of programers toward their work may be of singular importance, and that they represent a fertile area in need of inquiry and research.

I will now deal briefly with two or three other "factors." The suggestion that the programer needs to be both flexible and compulsive may appear paradoxical. But unless he is able to "give up one of my best frames," and still direct his efforts toward completing his task, he cannot hope to reach the stage where he can observe his program teach *real* students—the persons for whom the program was intended.

We have currently adopted a procedure for indoctrination of programers at Fort Bliss that may provide the beginner with rapid feedback on his first programing attempts, and at the same time facilitate an early evaluation of his potential as a programer. The procedure is simply that of assigning him the task of programing a relatively restricted and finite bit of subject matter as his first activity. We have not had sufficient experience with this approach to be able to evaluate it fully, but the consensus of the other programers is that it will be most useful.

If one accepts the basic premise that progress in programing is primarily a function of the programer rather than of the content of the program, one conclusion seems clear. Agencies and institutions contemplating the preparation of programs must recognize at the outset that the selection and training of programers is equally as important as are decisions about what material shall be programed, what kinds of mechanical devices shall be used, and what modes of presentation are most useful.

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RESEARCH PROBLEMS RELATED TO THE IMPLEMENTATION OF PROGRAMED INSTRUCTION[1]

Robert G. Smith, Jr.

This paper points out the necessity for certain kinds of research for data pertinent to the decision process, selection, training, and supervision of programers, and to the management of the learning process. Research is also needed in the areas of student motivation, disciplinary management of students, and instructor scheduling, and in the use of simulators, training devices, and equipment as part of the training program.

INTRODUCTION

Many of the initial research studies conducted in the field of programed instruction might be termed "demonstration studies." These studies demonstrated that significant improvements in learning could be brought about through the use of programed instruction. Next there was a series of studies concerned with attempts to identify variables affecting the learning process within the framework of programed instruction.

Recently, however, there has been an upsurge in activity designed to implement programed instruction and to bring it out of a purely research and experimental phase. The purpose of my paper will be to point out that those organizations which are called upon to assist others in the actual use of programed instruction are encountering a series of problems concerning which research data are greatly needed. One of the frustrating aspects of the present situation is that although a researcher must obtain some of the needed information purely in the course of preparing a program, some of this information is seldom reported.

THE DECISION PROCESS IN PROGRAMED INSTRUCTION

Data are needed relevant to the process of making the decision whether to use or not to use programed instruction. Most practical training people are quite aware of the fact that one seldom gets something for nothing. This is particularly true in programed instruction. In programing you increase the expense of the preparation of a training program, with the hope of obtaining a significant gain in proficiency or a reduction in time.

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[1] Paper for annual meeting of Southwestern Psychological Association, Fort Worth, Texas, Spring 1962.

Unfortunately, it is difficult to estimate the amount of time that will be saved by the use of programed instruction. The published data vary considerably. It is not surprising that this variation should exist, because we usually know very little about the quality of the conventional course or about the quality of the program against which the conventional course was prepared. It would be desirable if some rigorous work could be done to identify rather clearly those situations in which the greatest reduction in time could be expected from programed instruction, as opposed to those situations in which little reduction could be expected. Data on the amount of gain in final achievement or the amount of time saved as affected by various factors would be very significant information to have when one is facing a skeptical training executive.

Let us suppose that we have convinced our skeptical training executive that possibly he could use programed instruction. The next logical question is, where to get a program? We tell him that he can buy a program already developed by somebody and available for sale, or he can hire a contractor to build a program just for him, or he can develop a programing staff and build his own.

With regard to purchasing programs already available, there is a need, not for research, but for the development of appropriate professional standards. In the present burgeoning and changing state of the art, it might be premature to set standards that all programs have to meet, but it is not too early to consider preparing specifications of the information that should be made available to the prospective purchaser of a program. If we had professionally developed standards for reporting certain kinds of information about programs, it would make the decision of whether to use "off the shelf" procurement much easier. At a minimum, it would appear desirable to have a statement of the objectives of the program, a statement of the intended student population, and data concerning results that have been obtained by means of the program.

It is, of course, quite likely that our training executive will not find a commercially available program to meet his particular requirements. So he may consider the possibility of contracting for the preparation of a specially designed program. Again, he is faced with a decision process. How is he to know that a particular contractor is likely to deliver a useful product? Admittedly, programing practices vary widely, but the outlines of certain kinds of consistency are beginning to emerge, at least in the practices of the few groups with which I am familiar. It would seem quite reasonable to require that a contractor provide his prospective client with a complete description of the processes by which he plans to develop the programs so that they may be judged against whatever conventions the current state of the art suggests constitute good practice. But suppose our training executive says, "I don't trust outsiders to build programs for me; I think I had better get my own programing staff." At this point he is acquiring a large number of problems on which we have very scanty data. The requirement for information here is extensive.

THE PROBLEMS OF MANAGING A PROGRAMING STAFF

Selection

The earliest programs were usually prepared by people who were enthusiastic about the possibilities of programed instruction and who prepared programs covering material they already knew. These people usually turned out programs in what might be considered a reasonable amount of time. It is the common experience of people who have programing staffs to discover with a shock that not everybody can program. In some instances this may have to be restated as "Everybody *won't* program." Based on extremely limited experience, it would appear that the major variable involved might well be attitudinal. At the present time, about the only selection system that is used consistently is the "hire, try, and fire" system. Of course nearly everybody we have talked to admits that this is not very efficient; some of them have developed their own hypotheses about how to select programers, but we really know very little. Shop talk among programing groups is full of such statements as, "A good programer is where you find him."

Training

Currently most people appear to be learning how to program by means of a kind of apprenticeship. They become generally knowledgable in the field of programing by means of reading, discussions, work shops, and so forth, and then try their hand at preparing programs. It seems to take two to four months of this type of activity before the programer becomes reasonably proficient. A real difficulty in training stems from the fact that the most effective teachers of the programer are the students on whom he tries out his draft program. Research is needed to develop effective and quicker methods of obtaining programing proficiency. Obviously, before we can improve the proficiency of programers by improved training methods, we need to know how to measure the proficiency of programers. How do we tell a good programer from one who is not quite so good?

I have mentioned that one hypothesis about the selection of programers is that they should have appropriate attitudes. We have found that certain kinds of attitudes appear to interfere with the process of developing programs quickly. One attitude is expressed by the view that the individual already knows how to teach something, and doesn't quite see the need for all this programing rigmarole. Of course we do not know whether this attitude is a positive factor in poor performance or whether it is a rationalization for poor performance, but we do know that we need to have effective techniques for overcoming attitudes that appear to interfere with the process of developing programing skill.

Supervision

Most programers appear to find it difficult to work steadily for eight hours a day. Nevertheless, unless some control is exercised over the nature and duration of breaks, a supervisor may find that a programer who has struck a slow and difficult period will be interfering with the progress of those programers who happen to be suddenly at a stage where it is quite easy for them to turn out many frames. We need to have reports on the accumulated experience of groups with programing staffs. At the present time, case histories would be most welcome, although it is hoped that as the field develops there will be experimentation.

Another supervisory problem concerns the internal editing and review of the program before it is ready for testing on students. It seems obvious that certain kinds of editing for consistency are desirable, as well as review for the accuracy of technical content. At the same time, it is quite clear that continued interval review quickly reaches a point of diminishing returns. Successive polishing of a program may make it communicate very well with other programers, but may interfere in communication with students.

There is one source of data available from everyone who programs, but which not everyone reports. This is information concerning production rates. I do not mean production rates just for the writing of frames, because this is only one aspect of the preparation of the program. Extremely useful information for estimating the cost of preparation of programs, even on a "ball park basis," could be obtained if people would report how long it took them to accomplish different aspects of the programing process. How many man-hours were spent in preparing clear objectives, how many in preparing a criterion test, in outlining the content to be presented in the program and determining its sequence, in writing the frames, in pretesting the program, in program revision?

RESEARCH PROBLEMS IN THE MANAGEMENT OF THE LEARNING PROCESS

Another need for research is created by the tremendous differences between programed instruction, with its emphasis on individual rates of progress, and conventional instruction. Most training organizations have had many years in which to work out the administrative and other management problems associated with scheduling classes of specified length. They have had very little experience with courses in which the student progresses at his own rate. We need research studies aimed at developing efficient techniques of both intrinsic and extrinsic student motivation, disciplinary management of students, instructor scheduling, and the problems involved with potential bottlenecks when expensive simulators, training devices, or actual equipment are used as part of a training program.

In summary, recent developments in the use of programed instruction have created a need for certain kinds of research. We need data pertinent to the decision process, selection, training, and supervision of programers, and to the management of the learning process.

PROGRAMMED INSTRUCTION—WHERE WE ARE TODAY IN THE MILITARY[1]

William H. Melching

Acceptance and application of programmed instruction to the training problems of the Air Force and the Army are discussed in this paper. Programmer training workshops are described.

In general, the military services have shown a somewhat cautious interest in the possible application of programmed instruction to their training problems. In some instances reactions have ranged from unalloyed enthusiasm to open antagonism, but, by and large, the prevailing attitude has been positive.

On the basis of my experience, it seems easier to interest Army school instructors in the use of programmed instruction than to interest many college educators in its use. That this casual observation portends anything significant is doubtful, of course. Perhaps the military is more willing to accept the fact that there is a continuing need to improve training, while educators are interested in education—not in training.

When one searches the literature to find studies or experiments conducted by the military in which programmed instruction has been compared with another method of instruction, or in which experimental studies of programming variables have been involved, very few such efforts are found. Most of the work in this area to date has been accomplished by nonmilitary agencies.

At the same time, however, military and military research agencies have produced many theoretical and survey articles about programmed instruction. Let me list six as a brief sample:

Carr, *Self-Instructional Devices: A Review of Current Concepts*, Wright-Patterson AFB, August 1959.

Ekstrand, *et al.*, *Teaching Machines in the Modern Military Organization*, Wright-Patterson AFB, August 1960.

Ugelow, *Motivation and the Automation of Training: A Literature Review*, Wright-Patterson AFB, March 1962.

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[1] Paper for Symposium "Programmed Instruction—Where We Are Today," at Texas Psychological Association meeting in San Antonio, Texas, December 1962.

Darby, *An Annotated Bibliography on the Automation of Instruction*, HumRRO Research Memorandum, July 1959.

Silverman, *Automated Teaching: A Review of Theory and Research*, Naval Training Device Center, June 1960.

Marine Corps Equipment Board, *Automatic Teaching Machine, Devices; First Interim Report (Part I)*, Quantico, Virginia, July 1961.

I think these reports are encouraging evidence of the early interest of the military in this new technique. I would suggest that a movement toward implementation is now in progress, and that we can expect the military to become an ever-increasing consumer of programed learning techniques.

Let us look at some specific activities. At this time I have no information about implementation efforts within the Navy, so my remarks will be limited to the Air Force and the Army.

We could probably begin at no better place than with Colonel Ofiesh's statement of the Air Force program in programmed instruction.[1] Under its Air Training Command, the Air Force has undertaken a study of the technique in two phases.

In Phase I, programmed learning techniques were to be applied on a restricted and limited basis to current training problems within the Air Force. Accompanying this was the desire to develop a limited in-house capability in programmers. On the basis of replies from a questionnaire sent to over 140 institutions, companies, and individuals claiming competence to instruct in programming, contractors were selected and formal courses lasting two to three weeks were initiated.

Students were required to work in teams of two or three, each class consisting of approximately 20 students. Subject matters to be programmed were assigned to the students prior to entrance into the course, and only one of three basic approaches (linear, branching, or mathetics) was taught in any one class.

After the course, the students returned to their home bases and continued work on their programs. During the next few months, students met with their course instructors for additional assistance in the development of their programs. Once completed, each program is being subjected to experimental test to determine its effectiveness in comparison with the conventional method of instruction.

As of September 1962, approximately 200 Air Force personnel and civilians had received training in programming, and some 100 programs were being written. Field tests of these programs will occur soon. The Air Force plans to train an additional 100 programmers, at which time the first phase will be completed.[1]

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[1] Gabriel D. Ofiesh. "The Air Training Command Program in Programmed Instruction," Headquarters Air Training Command, Randolph AFB, Texas. Paper presented to: (1) the Armed Forces Section of the Department of Audio-Visual Instruction, National Education Association, Kansas City, March 1962; (2) at a Symposium at the Southern Society for Philosophy and Psychology at Memphis, April 1962.

Phase II will consist of an expanded utilization of the capabilities developed in Phase I, and the extent of the expansion will be dependent on the success achieved in the first phase. The primary criterion of success, of course, will be measured in terms of the efficiency of the programs developed.

In summary then, we can see that the Air Force has sought to explore the technique in a limited and controlled way so that final judgment can be deferred until sufficient data are obtained. Certainly by the end of Phase I, it will have developed a sizable in-house capability for programming. Upon attainment of positive results, the Air Force should be in an enviable position to obtain full benefit from its experiences.

Let us turn to the Army where there has been a gradual increase in interest in programmed instruction during approximately the past four years. A large portion of Army effort has been exerted through the Human Resources Research Office. Several research units within HumRRO have initiated exploratory work in this area, but research under TEXTRUCT at Fort Bliss, Texas, has been particularly concerned with evaluating the feasibility of programmed instruction for Army technical training.

Recently, while this research was under way, program contractors and manufacturers of teaching machines began approaching Army schools with offers of programs, devices, and so forth, and it became apparent that Army personnel would be likely to need information about programmed instruction to enable them to evaluate these offers. At about the same time, an interest in the possibility of developing an in-house capability for Army programming began to arise, and this led quite naturally to the decision to let HumRRO offer a series of workshops. Accordingly, at Fort Bliss plans were developed for a two-day orientation workshop for supervisory level personnel, and a two-week workshop to train programmers; each of these has now been conducted four times. More than 100 students have completed the programmer training workshop.

It may be interesting to note some of the differences and similarities between the programmer training workshops of the two services. Course length has been approximately the same, and the number of students in attendance at any one class has also been approximately equal. Army students have been encouraged to work in teams, but this has not always been possible. The subject matters brought for programming by

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[1] Gabriel D. Ofiesh, "Developing an In-house Capability in Programmed Instruction for Large Scale Systems," Headquarters Air Training Command, Randolph AFB, Texas. Paper presented at a Symposium at the American Psychological Association, St. Louis, September 1962.

Army students were assigned by their respective department or division heads, but it is not known whether the students were instructed to complete their programs following the workshop.

Whereas Air Force students received instruction in only one programming approach, each Army workshop introduced three. Primary emphasis was placed upon linear programming, but branching was also introduced, as well as a variation of linear programming we have called *looping*. Each student was free to attempt whatever approach most appealed to him. The particular approach was usually based on the student's evaluation of his subject matter, the anticipated variation in background of his students, and his own preferences.

It was not unusual for students to exhibit considerable ingenuity in this situation, reflecting in part their reluctance to adhere to only one approach. Also, some students employed one technique during the workshop, but indicated that they intended to use another when they returned to their home posts. Students were encouraged to initiate requests for consultations when they felt the need for assistance with their work following formal classes.

The decision to train additional programmers will rest directly within the Army, and HumRRO will probably not continue its workshops. As a sequel, however, the Fort Bliss Unit will attempt to automate portions of its workshop for training programmers, and this program will become available to Army schools.

In addition to the HumRRO work in programmed instruction already described, several independent programming endeavors have been undertaken within the Army school system. The same general situation may well prevail in the other service branches.

At the U.S. Army Signal School at Fort Monmouth, New Jersey, programs in both Direct and Alternating Current have been prepared and are being used on a trial basis. A program in Communication Procedures has been developed at Fort Gordon, Georgia, and the programming of additional course material is under way at this time. The Ordnance School at Aberdeen, Maryland has developed branching programs in Supply and Stock Levels, and current plans call for a continuation of this effort.

Each Department of the Air Defense School at Fort Bliss has been directed to prepare programs covering two hours of selected regular course work. The Basic Electronics Department of this school has completed a program in Direct Current and is presently constructing a program in Alternating Current.

It is significant that most military reports on the topic of programmed instruction do not deal with the question: "Is programmed instruction an efficient and effective method of instruction?" but rather ask: "How can programmed instruction be effectively implemented?" In other words, there seems to be rather widespread acceptance of the technique as an effective instructional tool. The difficult tasks center around the selection and training of programmers, the development of programs, and the integration of program packages into ongoing training systems.

In summary I would suggest that programmed instruction in the military today has passed the initial exploratory stage and is now on the threshold of implementation. The speed with which implementation will occur is debatable, but interestingly enough, seems to be not too dependent on a demonstration of great success in initial studies. This conclusion is easily reached by reading summaries of some earlier studies. Even though the results may not be highly supportive of programming—that is, even when programmed instruction is only equal to or partly superior to conventional instruction—the reports invariably and with an expressed intent to continue work in the area. Military researchers are certain that programmed instruction must not be prematurely discarded.

APPENDIX[1]

THE AUTOMATION OF INSTRUCTION

R.R. Ridenour

Task TEXTRUCT

U.S. ARMY AIR DEFENSE HUMAN RESEARCH UNIT
FORT BLISS, TEXAS

The purpose of this pamphlet is to acquaint you with a new method of instruction, quite different from any you previously have been exposed to. In the box below there are five questions important to your understanding of learning and automated instruction. After you have read the remaining pages in this pamphlet, you will be able to answer these questions and understand how important they are to the field of education.

I. What is automated instruction?

II. What is the purpose of automation studies?

III. What are three of the most important principles of learning?

IV. How can these principles be applied?

V. How might automated instruction affect the student and the teacher?

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[1] This brochure by Richard R. Ridenour was distributed at the International Science Exhibit, El Paso, Texas, March 1960. A device for teaching meter-reading was displayed and "troop-tested" by HumRRO.

I. WHAT IS AUTOMATED INSTRUCTION?

The term "automated instruction" or "teaching machine" is used to describe a method or device that can act as a private tutor for an individual student, without the need for continual attention from a human instructor. In this way, each learner is provided with just the information he needs at the time he needs it, thereby allowing him to progress at his own best rate of speed. Automated instruction is a procedure which insists that the student, rather than the teacher, is the most important element in the learning situation and it is designed to change the learner from a passive receiver of information to an active participant in the process of learning.

II. WHAT IS THE PURPOSE OF AUTOMATION STUDIES?

The reason for the recent concern with instructional automation methods is that the science of learning is quite well established but is not, at present, effectively used to the full extent of its potential. It has become increasingly apparent that it is impossible to apply the science of learning most effectively in the classical classroom situation. In the classroom, instruction must be geared for a group of different individuals instead of being aimed at the single student and varied according to his own needs. Thus, research on automation is an attempt on the part of the researchers to learn how to apply the actual science of learning in the most effective manner possible.

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III. WHAT ARE THREE OF THE MOST IMPORTANT PRINCIPLES OF LEARNING?

1) The Principle of Participation

This principle states that the learner must actively engage, or participate, in the learning. We all know that a person "learns by doing." What does this actually mean? Reading, listening, or watching are doing "doing" but in a passive rather than active way. The learner must participate actively by being forced to think and act by answering questions after each bit of information presented. He must practice those activities which he is expected to learn. It has been experimentally shown that active participation normally leads to more effective learning.

2) The Principle of Immediate Knowledge of Results

This, our second principle, is really two principles in one: the principle of knowledge of results and the principle of immediacy. By this we mean that the learner must know whether or not his answer to a question is correct and he must also know immediately. A lapse of even a few seconds following the answering of a question, and before the result of the answer is known, often leads to ineffective learning. Thus, it is essential to design a learning environment in which knowledge of results may be provided immediately.

3) The Principle of Individual Differences

In the same way that people differ with respect to height, weight, etc., they also differ as to the rate at which they learn. Since some people learn faster and some slower, material must be sequenced and presented according to the needs of the individual learner, if effective instruction is to be achieved.

There are, of course, many other established principles of learning. However, the above three are a sample of some of the most important.

IV. HOW CAN THESE PRINCIPLES BE APPLIED?

These principles cannot be applied effectively in the typical classroom. It is necessary to design a new kind of learning environment in which the principles can be applied.

There are several ways to apply the principles of effective learning. One way is the teaching machine. Another way is the specially sequenced or programmed textbook. The main problem facing researchers is not which "machine" (or instructional method) to use. Rather, it is how to present, or sequence, the subject matter in the most effective way.

V. HOW MIGHT AUTOMATED INSTRUCTION AFFECT THE STUDENT AND THE TEACHER?

1) The Student

Introduction of automated teaching in the school curriculum would tend to give the learner a feeling of personalized instruction, tailored to his own needs. By this we mean, a student would be allowed to learn at his own rate and at his own convenience. Material presented would depend upon answers to previous questions. For these reasons, it is to be assumed that automated instruction would tend to greatly increase student motivation and desire to learn by taking away some of the typical drudgery of study and replacing it by interesting individualized instruction.

2) The Teacher

Teaching devices will not in any way replace the human teacher. What it will do is to free the teacher from much routine instruction, thereby allowing him to give individual help to slower students and to assist faster students in their pursuit of more extensive knowledge of the subject. Due to this change in his job, teacher prestige should be greatly enhanced.

The following is a short quiz to see how well YOU have understood the principles of learning and effective teaching. Try answering the following questions in order to see if our explanation has been clear. You will find the answers on the next two pages. Check your answer on pages 6 and 7 after each question and before going on to the next.

1. **Which is more effective for learning, active "thinking" participation or passive listening, watching, or reading?**

   a) Active
   b) Passive

   (Turn to pages 6 and 7 for the correct answer.)

2. **Which of the following is most likely to assure immediate knowledge of right or wrong?**

   a) A lecture
   b) A small class
   c) A private tutor

3. **If a test or examination is to be effective as a learning experience, when is the best time to give the learner knowledge of results?**

   a) As soon as he answers each question
   b) As soon as he has finished the test
   c) As soon as the teacher has finished grading and recording the papers

4. **To insure understanding and prevent boredom on the part of the learner we must direct our teaching at the individual. Which of the following does this best?**

   a) A lecture
   b) A teaching device
   c) A small class

5. **From the standpoint of effective learning, which of the following is the best way to present material?**

   a) Television
   b) A lecture
   c) Individual "active" instruction
   d) A textbook

6. **Which of the following is the most effective way to teach?**

   a) A large lecture
   b) A small class
   c) A "good" private tutor, machine or otherwise

ANSWERS

1. You certainly answered "active participation" is the more effective because the learner is forced to "think" and understand the material presented.

2. "A private tutor" is correct. Under individual situations the student can immediately ask a question and receive an answer.

3. The principle important here is that relating to the immediacy of knowledge of results. Hence, you were correct if you said, "as soon as he answers each question." If the test is for the purpose of student evaluation only, and learning is not expected, then it doesn't matter when the results are made known.

4. What else? "A teaching device." A lecture or class must be prearranged as to content and must be directed, with respect to difficulty of the material, at the capabilities of the middle or the lower part of the class.

5. You said "individual active instruction," I am sure. Of the choices offered, it most effectively embodies the learning principles.

6. Finally, the best way to teach must be by a "good" tutor, machine or otherwise, because the other methods, by nature, cannot fully utilize the science of learning.

1. Machine or "device" teaching requires the learner to actively participate by asking questions immediately following each bit of information.

2. When automated, the "machine" asks questions and the student must answer before proceeding. Some machines have been devised where the student can ask questions of his own. But the principle of "active participation" can be fulfilled by the machine doing the asking.

3. Teaching devices are designed so that the learner is always informed of the accuracy of his responses as soon as he makes them.

4. A "machine" teaching program can present material as it is required by the individual student. The question of what information should come next is determined by how well the student answers the questions.

5. Automated teaching gives individual active instruction and places the emphasis on the individual and the science of learning.

6. The "tutor" combines the principles of learning with an effective learning environment to emphasize–learning.

SUMMARY AND CONCLUSIONS

The idea of automating instruction is not new (original patent taken out 1866) but real interest in the great teaching possibilities inherent in the concept has only been evidenced in the past three years. In such a short period of time the research has only served to promote interest and demonstrate the vast possibilities of combining subject material and the science of learning. Research is aimed not at deciding what subjects to teach but at how to teach them. In this pamphlet we have been mainly concerned with the scientific principles of learning and the possibility of their application to automated instruction. It is important to remember that although the machine contributes to an effective learning environment, the most important aspect of automated instruction is not the "gadgetry" but the learning material which is placed within the machine and the way it is presented. The most spectacular machine is of absolutely no value unless the "program" of instruction has been carefully and accurately constructed to best fit the needs of the individual learner. All "machines" and the material to put in them are in a strictly experimental stage. However, it is expected that great changes will be made in the next few years which will radically advance the educational situation in our country. The thought is not to replace our institutions of learning or our teachers; the idea is to increase their teaching capabilities through the application of scientific learning methods. We are living in a continually changing world, yet education is still much the same as it was a hundred years ago. Automated teaching offers a great possibility of bringing education up to date.

OTHER PUBLICATIONS UNDER WORK UNIT TEXTRUCT

An Annotated Bibliography on the Automation of Instruction, Research Memorandum by Charles L. Darby, July 1959. PB-159959 AD-228 766

An Evaluation of an Experimental Meter Reading Trainer, Research Memorandum by Robert G. Smith, Jr. and Richard R. Ridenour, October 1960.
AD-815861L

Results of Exploratory Investigations Conducted for the Purpose of Planning a Research Program on Instructional Methods, Research Memorandum, March 1961.
AD-253 395

Teaching Machines and Programmed Instruction—Some Factors to Consider in Implementation, Research Memorandum by Robert G. Smith, Jr., August 1961.
AD-632 188

A Procedural Guide to the Programming of Instruction: Preliminary Report, Research Memorandum by William H. Melching, March 1962.
AD-279 569

The Text of an Orientation Workshop in Automated Instruction, Consulting Report by William H. Melching, John A. Cox, Jesse C. Rupe, and Robert G. Smith, Jr., July 1962.
AD-637 117

Studies of Fixed Procedures Training: A Preliminary Test of Self-Instructional Method, Research Memorandum by Paul G. Whitmore, July 1963.
AD-420 453

A Handbook for Programmers of Automated Instruction, procedural guide by William H. Melching, Robert G. Smith, Jr., Jesse C. Rupe, and John A. Cox, September 1963.
AD-632 558

Evaluation of an Auto-Instructional Program on the First Week of a Basic Electronics Course, Research Memorandum (revised) by William H. Melching, Harold E. Christensen, and Albert L. Kubala, March 1964.
AD-601 681

The following research materials were among those prepared under Work Unit TEXTRUCT:

Pocketschool Series, manuals for experimental teaching program (published by U.S. Army Air Defense School), July 1960.[1]

Mathematics I, Multiplication and Division (Decimals):
Part One, Part Two, Part Three

Mathematics II, Multiplication and Division (Cancellation)

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[1] Volume IX and Supplemental Graph Book were published by Division No. 5 (Air Defense), June 1963.

Mathematics III, Powers and Roots:
    Part One, Part Two

Mathematics IV, Powers of Ten

Mathematics V, Simple Equations:
    Part One, Part Two, Part Three

Mathematics VI, Proportions:
    Part One, Part Two

Mathematics VII, Stated Problems:
    Reference Items for Parts One and Two
    Part One, Part Two, Part Three

Mathematics VIII, Nomograms

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13. ABSTRACT

Research in the area of instructional methods for technical training is reported in this collection of 12 papers: "Teaching: Today and Tomorrow," by Robert F. Mager; "Preliminary Studies in Automated Teaching," by Robert F. Mager; "Developing New Instructional Techniques," by P.G. Whitmore; "The Effectiveness and Implementation of Instructional Closed-Circuit Television," by Staff Members of HumRRO Division No. 5 (Air Defense); "Automated Instructional Methods for Technical Training," by Paul G. Whitmore; "Deriving and Specifying Instructional Objectives," by Paul G. Whitmore; "Military Control—A Frequently Missing Training Opportunity," by Robert G. Smith, Jr.,; "A Rational Analysis of the Process of Instruction," by Paul G. Whitmore; "Some Research Needs in Selecting and Training Programmers," by William H. Melching; "Research Problems Related to the Implementation of Programmed Instruction," by Robert G. Smith, Jr.; "Programmed Instruction—Where We Are Today in the Military," by William H. Melching; "The Automation of Instruction."

14.

KEY WORDS	LINK A		LINK B		LINK C	
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